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SUSTAINABILITY LOGISTICS BASING SCIENCE AND TECHNOLOGY OBJECTIVE – DEMONSTRATION #1 – 1000 PERSON CAMP DEMO

by

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14. ABSTRACT
This report documents the objectives, technologies, methods, and results of a Sustainability/Logistics-Basing Science & Technology Objective – Demonstration (SLB-STO-D) at the Contingency Basing Integration and Technology Evaluation Center (CBITEC), Fort Leonard Wood, MO. The goal of the SLB-STO-D is to demonstrate emerging materiel solution technologies and associated non-materiel solutions that can reduce the need for fuel resupply by 25%, for water resupply by 75%, and for waste removal by 50%, while maintaining or improving the quality of life at expeditionary base camps. The SLB-STO-D is using modeling and simulation, closely integrated with field demonstrations, to show fuel, water, and waste savings attributed to these technologies. Technologies demonstrated at CBITEC include Modular Appliances for Configurable Kitchens (MACK), Desert Environment Sustainable Efficient Refrigeration Technology (DESERT), Real Time Inline Diagnostic Technology for Water Monitoring (WATERMON), Wastewater Treatment (WWT-Bio), PowerShade Cost Reduction (PSHADE), Energy Informed Operations (EIO-C), Deployable Metering and Monitoring System (DMMS), Hybrid Power Trailer (HPT), and Structural Insulated Panel Hut (SIP-Hut).

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WASTE BASE CAMPS DEMONSTRATIONS CONTINGENCY BASING SUSTAINABILITY
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The Sustainability/Logistics-Basing Science and Technology Objective – Demonstration (SLB-STO-D) Experimentation, Demonstration, and Validation Team (EDVT), supported by the functional teams of the SLB-STO-D, conducted the second installment of Demonstration #1 during the period 7-24 April 2015 at the Contingency Basing Integration and Technology Evaluation Center (CBITEC), Fort Leonard Wood, MO to collect data on technologies that support the objectives of SLB-STO-D. This event, managed by the Natick Soldier Research, Development and Engineering Center (NSRDEC), was borne out of the execution of the approved Project Plan (version 3.0, dated 19 April, 2013), the Integrated Master Schedule (IMS), and the Systems Engineering Plan (SEP). This report fully supports the directives established therein to document the objectives, materials, technologies, methods and results of data collection events in support of the SLB-STO-D. Datasets associated with this demonstration were delivered to the SLB-STO-D's Lead Systems Engineer and are summarized in this report. Other functional teams, such as the Modeling, Simulations, and Analysis Team, will use the data collected during this demonstration to conduct analysis related to the SLB-STO-D objectives and publish those findings and results under a separate cover.

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EXECUTIVE SUMMARY

The Sustainability Logistics Basing-Science and Technology-Demonstration (SLB-STO-D)[1] is a Department of the Army-approved program that seeks to enable independence/self-sufficiency and reduce sustainment demands at contingency bases. The Army's need to reduce the sustainment demands at contingency bases is driven by the imperative to minimize the number of resupply convoys and associated ground and air protection, thus ultimately reducing the threat exposure hours for Soldiers subject to life threatening scenarios. In addition, the rising costs of resupplying expeditionary forces and waste backhaul (i.e., fuel and water consumption and waste generation) will be greatly reduced.

SLB-STO-D intends to reduce the costs and risks associated with increasing resupply/logistical burden at expeditionary bases by developing and integrating technologies along with non-materiel solutions that demonstrate an optimized integrated approach to reducing sustainment requirements for small contingency base operations. The programmatic goals of SLB-STO-D are to reduce fuel consumption by 25%, water consumption by 75%, and waste generation by 50%, while maintaining or improving the quality of life of Soldiers at expeditionary bases in the size range of 50–1000 personnel. SLB-STO-D will show how these goals can be achieved by the fourth quarter of 2017.

The SLB-STO-D cannot demonstrate all variations of technologies and current base camp systems in multiple environments and multiple configurations, so a Model-Based System Engineering (MBSE) approach is key to document how to meet the goals stated above. Performance data collected as well as integration details and Soldier feedback collected during these demonstrations will be used to create technology models, architecture views, base camp configurations and simulations that provide the rigor and documentation that will support the analysis conclusions.

In order to achieve the programmatic goals and meet the 4Q2017 schedule, SLB-STO-D will seek out fairly mature applicable technologies (i.e., Technology Readiness Level 5 (TRL 5) or above) and will conduct multiple operationally relevant integrated demonstrations in FY15 and FY16 to determine their capabilities to contribute to the overall goals of the program.

The technology demonstrations were managed by the Natick Soldier Research, Development and Engineering Center (NSRDEC) and conducted in a series of operationally relevant trials of 50, 300, and 1000-personnel capacity venues. These venues are located at the Base Camp Integration Laboratory (BCIL) at Fort Devens, MA and the Contingency Basing Integration and Technology Evaluation Center (CBITEC), Fort Leonard Wood, MO. The BCIL and the CBITEC were selected for their ability to replicate operational environments in field contingency bases (e.g., billets, dining facilities, latrines, showers, etc.) and their unique instrumentation capabilities, which support data acquisition and authentication to enable subsequent analyses. The BCIL was selected to host the 50 and 300 personnel capacity venue, while the CBITEC was selected to host the 1000 personnel capacity venue.

[1] Formerly known as Technology-Enabled Capability 4a (TECD 4a) Sustainability/Logistics-Basing.

This technical report pertains to one physical demonstration that is part of the larger SLB-STO-D MBSE process: the events that transpired during the 1000-Person Base Camp Demo at CBITEC, Fort Leonard Wood, MO venue during 7-24 April 2015. These technologies and associated salient objective characteristics of the demonstrated technologies are as follows:

- Modular Appliances for Configurable Kitchens (MACK) – modular fuel-fired kitchen appliances that are designed to reduce fuel consumption and improve working conditions within Army mobile kitchens.
- Desert Environment Sustainable Efficient Refrigeration Technology (DESERT) – uses a higher efficiency refrigeration unit to replace the cooling systems used in existing Army 20-ft storage containers, thus reducing fuel consumption. Because the refrigeration unit can run directly on DC power, it can also be connected directly to alternative energy sources.
- Real Time Inline Diagnostic Technology for Water Monitoring (WATERMON) – reduces water resupply demand by providing real-time quality assurance information on water produced in the field. It also enables the performance optimization of water treatment equipment.
- Waste Water Treatment-Biological (WWT-Bio) – provides wastewater treatment capabilities at contingency bases to reduce wastewater backhauling.
- PowerShade (PSHADE) Cost Reduction – fabric structure with built-in photovoltaic array, storage, and a distribution system that is designed to shade and provide power to tents, rigid-wall shelters, etc. Reduces fuel consumption by providing power and diminishing heat loads.
- Energy Informed Operations-Central (EIO-C) – interface standard for an autonomous tactical microgrid architecture from 15 kW to 300 kW that supports Army Contingency Basing power availability and reliability, while reducing generator fuel usage and maintenance.
- Deployable Metering and Monitoring System (DMMS) – multi-component electronic system for monitoring, data acquisition, analysis, and information dissemination of base camp sustainment/logistics elements (e.g., energy, fuel, water, waste, etc.). It can provide Contingency Base commanders with information that could assist in making informed decisions about the management of energy, fuel, water, and waste.
- Hybrid Power Trailer (HPT) – electrical power generation system that couples a standard Army 15 kW tactical quiet generator (TQG) with an 80 kW-hr lithium ion battery mounted on a trailer. The system decreases generator run time, reduces fuel consumption, enables silent operation, and provides power redundancy for military applications.
- Structural Insulated Panel Hut (SIP-Hut) – alternative to semi-permanent barracks and are constructed of pre-manufactured quick assembly/disassembly structural insulated panels that have a high insulating value (both thermal and acoustic). The SIP-Hut takes one-third the time to construct and is twice as thermally efficient as the current B-Huts. It reduces the electrical power required on HVAC equipment, thus reducing fuel consumption on generators. It reduces the fuel requirements for heating, if fuel-fired heaters are used.

Data were collected on all systems using electronic instrumentation, i.e., automated data acquisition systems, and in some cases manual data collection methods (e.g., fuel consumption in

TQGs). The data were monitored, harvested, processed, and securely stored in a network storage device by a data librarian, who was responsible for the accuracy and integrity of the data. Periodic data reviews were conducted by a Data Authentication Group (DAG) to ensure the validity and fidelity of the data.

After completion of the demonstration all data was provided to the Modeling, Simulation, and Analysis Team (MSAT). They are responsible for the application of pertinent modeling and simulation methods and analysis of the data to garner results and draw conclusions pertaining to the efficacy of the technologies to meet water, fuel, and waste reductions.

It is worth noting that Soldiers participated in this demonstration in two key areas. First, 12 Non-Commissioned Officer (NCO) students and 1 instructor from the Prime Power School (PPS) participated in training and briefings on power-related technologies. Second, 11 Soldiers and NCOs from the 5th Engineer Battalion and the 92nd Military Police Battalion trained on the operation of the MACK and prepared meals in support of the field feeding operation and the Leadership Day. Each group participated in focus groups facilitated by the Consumer Research Team and other NSRDEC personnel. The focus group input from the Soldiers provided valuable feedback that has assisted and will continue to assist technology providers in improving their prototypes.

During the 1000-Person Camp Demo at CBITEC, the SLB-STO-D team was able to achieve the main objective of Demonstration #1, which was to collect empirical data on candidate and baseline base camp technologies to calibrate modeling and simulation models, and to conduct subsequent analysis. This objective was achieved and the datasets were delivered. The SLB-STO-D Lead Systems Engineer (LSE) has configuration control of this data and all data requests should be directed to the LSE.

Other notable accomplishments were:

- The demonstration was a huge success in many areas and reinforced much about what the project team has learned in terms of planning, preparation, and execution.
- Significant data was collected and the majority of it is very useful. There were some areas identified as "needs improvement," but overall the project team and candidate technologies met the demonstration objectives.
- Operationally, the EIO-C system was able to power the A-block billets for the entire occupation of the Military Police Basic Officer Leader Course (MP BOLC) class without loss of power.
- Venue coordination, logistics, integration with other systems and technologies, stakeholder engagements, data collection and authentication were done collectively, rather than requiring each individual project officer to organize and execute their own demonstration event. This represents a significant savings to the government in both time and money. More time was devoted to thorough data collection, and stakeholders could come to one event and see multiple technologies. An added benefit is that technology leads could interact with each other, the Project Manager community, and the TRADOC community.

- The demonstration allowed the Army's Research, Development, and Engineering Centers (RDECs) to encounter the challenges of integration in a "field" environment and to expose their technologies to Soldiers, who provided valuable feedback to improve their technologies, thus creating a "Win-Win" situation that can shorten the development and maturation cycles of the demonstrated technologies.
- This event received visits from several key leaders and was the subject of several newspaper articles and television news clips. Visitors included the Honorable Katherine Hammack (Assistant Secretary of the Army (Installations, Energy & Environment)), MG Duane A. Gamble (Assistant Deputy Chief of Staff for Operations, G4 Logistics), and Dr. Rebecca Johnson (Deputy to the Commanding General, Fort Leonard Wood), to name just a few.
- The MACK demonstrated its ability to save power using fuel-fired appliances in the successful execution of three field-feeding events. In each of these events, Soldiers conducted the entire exercise. Notably, the event that included feeding 800 people for one meal was successful in all regards.
- The DESERT refrigeration unit successfully kept rations at the needed temperature to support the MACK field feeding events.
- The WWT-Bio system continuously processed blackwater at the treatment facility for nearly 2 months.
- The DMMS system was able to successfully display energy related information in real time during the demonstration event. This type of information could be used by commanders to make energy decisions.
- The PSHADE technology successfully produced and stored power for use in the display area.
- The HPT was integrated with several other technologies, providing battery and generator power to the technologies as required.

The SLB-STO-D, and specifically the Experimentation, Demonstration, and Validation Team (EDVT), learned a number of lessons during planning, preparation, and execution of this and previous demonstrations, which will help to improve future demonstrations. The SLB-STO-D's data management processes were key to the success of this demo. These processes will continue to improve with experience as all functional teams dedicate the right manpower and resources early in the demonstration planning phase to identify and track the required data elements.

SUSTAINABILITY/LOGISTICS-BASING SCIENCE AND TECHNOLOGY OBJECTIVE – DEMONSTRATION

DEMONSTRATION #1

1000-PERSON CAMP DEMO

1. INTRODUCTION

This technical report documents the objectives, candidate technologies demonstrated, methods used, and results of the 1000-Person Camp Demonstration conducted under the U.S. Army Sustainability Logistics Basing-Science and Technology-Demonstration (SLB-STO-D) Program[1] and during the period 7-24 April 2015 at the Contingency Basing Integration and Technology Evaluation Center (CBITEC), Fort Leonard Wood, MO. This report does not include analysis of the data collected. That was a separate effort, following the demonstration, to be documented in a separate report. This demonstration was a joint venture between the Maneuver Support Center of Excellence (MSCoE), with the TRADOC Capability Manager Maneuver Support as the executive agent, and the Construction Engineering Research Laboratory (CERL), a component of the Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The CBITEC demonstration was the largest of three demonstrations held at three different-size base camps and managed by the Natick Soldier Research, Development and Engineering Center (NSRDEC) as part of the Integrated Demonstration Phase of the SLB-STO-D Program.

1.1 SLB-STO-D Program

The SLB-STO-D Program was approved by the Department of the Army in February 2012. At the center of the program is the problem the Army seeks capability to reduce/mitigate:

> The Army needs improved capability to enable sustainment independence/self-sufficiency and to reduce sustainment demands at expeditionary basing levels contingency bases. It is too costly, too unpredictable, and too labor intensive for a Small Unit to carry all required consumables to last for weeks or months at a COP/PB. Storage facilities and systems do not meet needs of these small bases, and resupply efforts are highly unpredictable.

This problem statement forms the basis for the program and lays the foundation for the formulation of the program proposal and is pervasively present in the program baseline. To put the problem in perspective, in 2011 contingency bases (all services) consumed approximately 254,000,000 gallons of fuel, which is equal to that of ground and air platforms combined (according to Assistant Secretary of Defense (ASD), Operational Energy Plans and Programs (OEPP)). At even a conservative figure of $10 per gallon (fully burdened cost of fuel), this represents a significant Operations and Support (O&S) cost. Equal to that is the risk that the significant tactical resupply burden required presents to the Soldier in the form of convoy incidents, etc.

The program uses modeling, simulation, and analysis to show a reduction in fuel consumption by

[1] Formerly known as Technology-Enabled Capability 4a (TECD 4a) Sustainability/Logistics-Basing.

25%, a reduction in water consumption by 75%, and a reduction in waste generated by 50% at base camps compared to an established technical and operational baseline. Conducting live demonstration and collecting data in an operationally relevant environment will be key to developing and validating the models that will be used to address this challenge.

To achieve the programmatic goals and meet the 4Q2017 schedule, SLB-STO-D will seek out fairly mature applicable technologies (i.e., Technology Readiness Level 5 (TRL 5) or above) and will conduct multiple operationally relevant integrated demonstrations in FY15 and FY16 to determine their capabilities to contribute to the overall goals of the program. Finally, a capstone event is planned for FY17 with the collaboration of acquisition partners.

One of the goals for all the demonstrations is to showcase technologies with the greatest impact to reduce fuel, water, and waste in base camps. Having a common venue for integration, empirical data collection, and Soldier interaction/feedback encourages communication between transition partners and other technology leads. This communication and learning has the potential to improve prototypes and ultimately improve technology transition to Programs of Record (PoRs).

1.2 Demonstration Concept

The full scope (to include planning window) of Demonstration #1 includes four phases – Planning Phase, Demonstration Preparation Phase, Integrated Demonstration Phase, and Analysis and Reporting Phase. Demonstration #1 consisted of three demonstrations based on SLB-STO-D baseline scenarios; a 50-person camp, a 300-person camp, and the 1000-person camp. Different technologies were demonstrated and integrated at each demonstration venue. Efforts for each demonstration were conducted during each of the four phases. Timelines for the three execution phases are shown in **Figure 1**. The Planning phase began with development of the first Demonstration and Assessment Master Plan (DAMP) in February 2012. The Demonstration Preparation phase began in April 2014 and featured testing of individual technologies by the respective technology developers. The Integrated Demonstration phase began with the 50-person base camp demonstration, which was conducted between 29 September and 17 October 2014 at the Base Camp Integration Laboratory (BCIL), Fort Devens, MA. It ended with the 300-person base camp demonstration, which was conducted during the period 7-31 July 2015 at the BCIL. The Analysis and Reporting Phase, which consists of modeling simulations of the data collected for the three demonstrations, began in October 2014. Because the SLB-STO-D cannot demonstrate all variations of technologies and current base camp systems in multiple environments and multiple configurations, a Model-Based System Engineering (MBSE) approach was key to meet the program goals.

The SLB-STO-D has five functional teams supporting the demonstration concept. The demonstration is led by the Experimentation, Demonstration, and Validation Team (EDVT), and supported by the other functional teams – Technology Maturation and Integration Team (TMIT), Systems Engineering and Integration Team (SEIT), Modeling, Simulation, and Analysis Team (MSAT), Requirements Integration Team (RIT), and the Core Leadership Team (CLT). These five teams conducted the three base camp demonstrations.

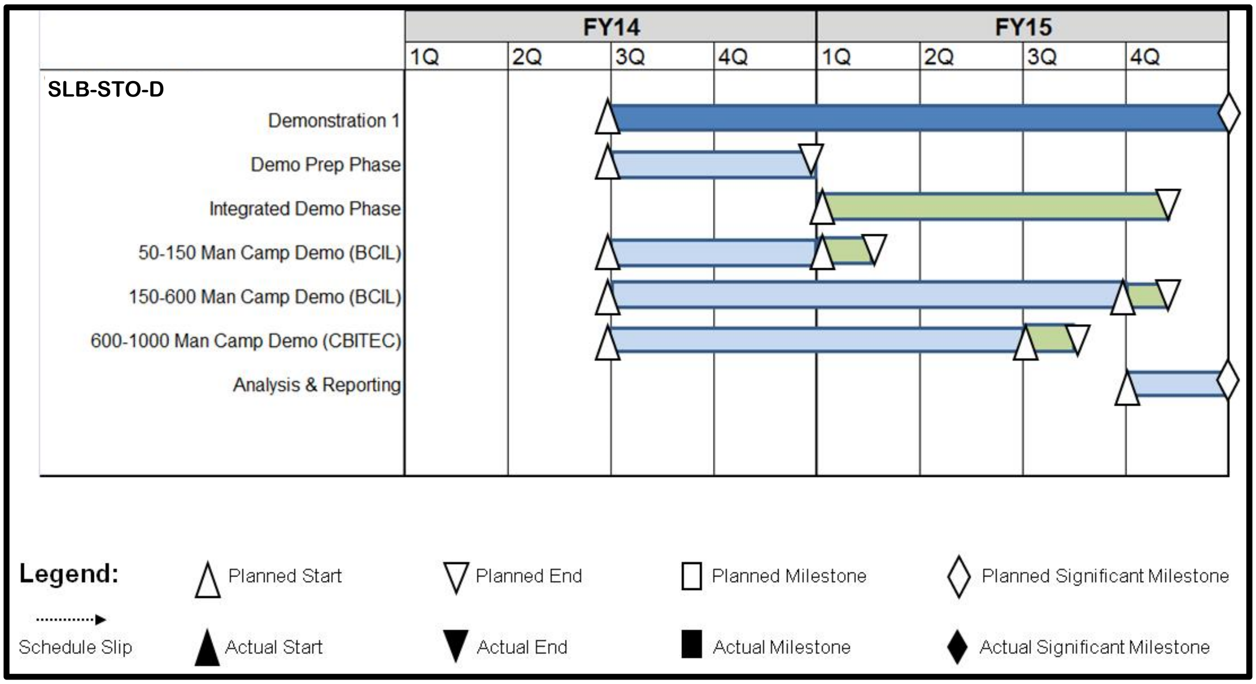

Figure 1: Demonstration #1 Execution Phases

1.3 Integrated Demonstration Phase Objectives

The specific objectives for the Integrated Demonstration Phase are:

- **Objective 1**: Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and support trade-offs and engineering decisions (main effort).
- **Objective 2**: Collect data on Quality of Life at the camp.
- **Objective 3**: Show how SLB-STO-D meets Contingency Basing (CB) and Operational Energy (OE) gaps.
- **Objective 4**: Showcase any “Wow Factors,” i.e., the materiel and non-materiel game changers.
- **Objective 5:** Present modeling and simulation methods and results as part of the demonstration through visual and physical displays, such as posters and computer representations of models.

1.4 Purpose of CBITEC Demonstration

The key purpose of the CBITEC demonstration was to collect data on selected candidate technologies and the 1000-person camp baseline systems in an operationally relevant environment. Data will be used as indicated in the Analytical Framework (**Figure 2**) and described in the SLB-STO-D Systems Engineering Plan.

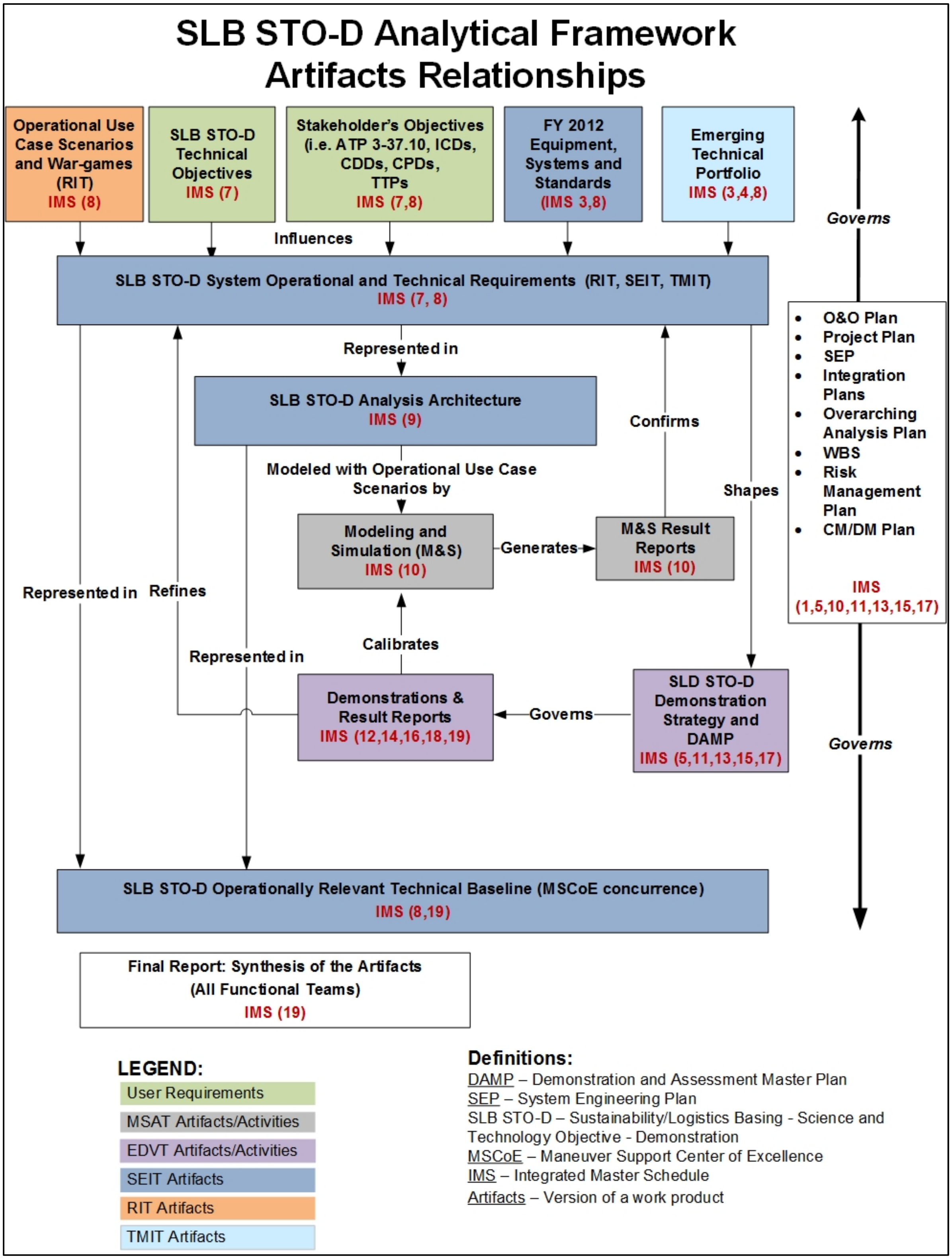

Figure 2: Analytical Framework

1.5 Key Events Related to CBITEC Demonstration

The demonstration at Fort Leonard Wood and the CBITEC featured a number of interesting events. To meet the objectives, systems were set up, instrumented, and operated either under routine conditions or according to a script to collect data. Layered on top of the data collection tasks were a number of events that rounded out the demonstration. The following is a list of the key milestones for this demonstration.

- **9 March** – Frontier Technology set up the Waste Water Treatment- Biological (WWT-Bio) system at the Fort Leonard Wood water treatment facility. The system operated there for nearly 2 months, until the end of April. This system was set up early so that the vendor could assess its performance in cooler weather.
- **7 April** – This was the first official day of the demo. Work began in earnest on setting up and instrumenting all the technologies.
- **13 April** – Official start of record runs for data collection. Students and cadre from the Prime Power School also visited this day.
- **15 April** – Convened the first meeting of the Data Authentication Group. Conducted a focus group session with the Prime Power School.
- **16-22 April** – Basic Officer Leadership Course class from the Military Police School occupied the CBITEC billets.
- **17 April** – Conducted training for the MOS 92G Food Specialists on the Modular Appliances for Configurable Kitchens. Prepared 200 meals.
- **21 April** – Conducted a field feeding operation for 800 Soldiers. Hosted the Honorable Katherine Hammack, Assistant Secretary of the Army (Installations, Energy & Environment).
- **22 April** – Conducted Stakeholder Day. Prepared 100 meals. Conducted a focus group session with the MOS 92G Soldiers.
- **24 April** – Completed data collection on most systems.
- **29 April** – Final meeting of the Data Authentication Group on site.

2. DEMONSTRATED TECHNOLOGIES

Nine of the SLB-STO-D candidate technologies were selected for participation in the 1000-person camp demonstration. These are listed below in **Table 1**. The technologies were originally proposed by the TMIT for inclusion in the SLB-STO-D. Then a panel of all functional teams selected the technologies for this demonstration based on relevance to camp size, availability, and projected maturity.

Table 1: Selected Technologies for 1000-Person Camp Demonstration

Tech ID Number	Project Name	Lab	POC	TRL	Thrust Area
EE-0700	Modular Appliances for Configurable Kitchens (MACK)	NSRDEC	Joseph Quigley	6	Fuel Demand
EE-0680	Desert Environment Sustainable Efficient Refrigeration Technology (DESERT)	NSRDEC	Alex Schmidt	6	Fuel Demand
EE-0820	Real Time Inline Diagnostic Technology for Water Monitoring (WATERMON)	TARDEC	Lisa Neuendorff	6	Water Demand
EE-0980	Wastewater Treatment (WWT-bio)	TARDEC	Lateefah Brooks	6	Waste
EE-0290	PowerShade Cost Reduction (POWERSHADE)	NSRDEC	Steven Tucker	7	Fuel Demand
EE-0360	Energy Informed Operations (EIO)	CERDEC	Michael Gonzalez	6	Fuel Demand
EE-1200	Deployable Metering and Monitoring System (DMMS)	ERDC	Tom Decker	6	Planning and Analysis Tools
EE-1210	Hybrid Power Trailer (HPT)	ERDC	Tom Decker	6	Fuel Demand
EE-1220	Structural Insulated Panel Hut (SIP-HUT)	ERDC	Tom Decker	6	Fuel Demand

2.1 Modular Appliances for Configurable Kitchens (MACK)

The MACK is a suite of modular fuel-fired kitchen appliances (**Figure 3**) that can be configured for use across all Army field feeding platforms. The modular appliances are designed to replace current fuel-fired appliances that are inefficient, loud, expensive, and exhaust heat and combustion products into the kitchen workspace.

Figure 3: Modular Appliances for Configurable Kitchens

Key features of the MACK are:

- Far quieter and easier to use than current appliances, and does not vent heat and exhaust into cooking area.
- Standardized design concept that minimizes number of inventoried parts, reduces the total number of National Stock Numbers (NSNs).
- Standard suite across all mobile kitchen platforms simplifies training; all kitchens use common components that can scale to outfit kitchens with different capacities.
- Modular nature of components enables easy disassembly into man-portable pieces for integration into different platforms or buildings.

- Compared to current JP-8 appliances, fuel is reduced by:
  - 50% on average across all appliance types.
  - Typical power requirements per appliance are reduced from approximately 90 W (Modern Burner Unit (MBU)) to 50 W (Joint Inter-service Field Feeding (JIFF) burner).

Technical Point of Contact: Joseph J. Quigley, joseph.j.quigley6.civ@mail.mil, 508-233-5860.

2.2 Desert Environment Sustainable Efficient Refrigeration Technology (DESERT)

The DESERT (**Figure 4**) project demonstrated a High-Efficiency Refrigeration Unit (HERU). The HERU is intended as a plug-and-play replacement to the cooling systems in existing Army 20-ft cold-storage containers, and utilizes the existing Multi-Temperature Refrigerated Container System (MTRCS) as the demonstration platform. Compared to legacy systems, the HERU is twice as efficient, twice as effective, and operates in extremely hot environments. Fuel savings greater than 50% are achieved solely through the higher efficiency, while additional savings are possible via the ability to interface with renewable energy sources such as solar photovoltaics. It includes an on-board generator set for backup power or for operation while mobile. This demonstration included a DESERT Power 2 (DP2) solar array (**Figure 5**), which is a standard Solar System I shade shelter modified by the inclusion of 2 kW of flexible solar panels. The array provides electricity simultaneously with conventional inputs, thus offsetting fuel use.

Figure 4: DESERT

Figure 5: DP2 Solar Array

Important characteristics of the HERU are:

- Even without solar assistance, the reduced energy requirement can save up to 730 gal[2] of JP-8/year/system = trucks off the road.
- Max power draw of 8 kW under demanding conditions, and no surge = smaller gensets.
- Doubled mean time between failures, from 500 to 1000 hours = greater reliability.
- High temperature capability to 135 °F ambient = operation in hot theaters.
- Greater reliability, hot climate compatibility, and cooling capacity = less food loss.
- 16% lower initial procurement cost = lower production cost and lower replacement cost.

[2] Fuel savings are dependent on how power is supplied to the HERU.

- No tradeoffs: this technology will meet and exceed all existing operational requirements.
- The computer diagnostics will ease maintenance.

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2.3 Real Time Inline Diagnostic Technology for Water Monitoring (WATERMON)

The WATERMON (**Figure 6**) system consists of a suite of sensors for In-line Water Monitoring applications. The system is a water demand reduction technology capable of providing quality assurance information for >30 days use of field water produced using new processing techniques. The system is also capable of enabling the performance optimization of water treatment equipment.

Figure 6: Current Manual Water Monitoring Process (Top) and WATERMON (Lower Left)

Other important characteristics are:
- Autonomous, battery powered.
- Wireless- and network-capable sensors compatible with most computing devices, smart phones, and media players.
- Interoperable with most water treatment and handling systems using supplied connections.
- Testing raw and product water <5% inaccuracy for each water quality parameter and <5 min total analysis time.
- Non-specific MOS operator can be trained within 2 hours.

While the WATERMON was being ruggedized for the July 300-person camp demonstration, the 1000-person camp demonstration approximated the WATERMON by integrating Commercial-Off-The-Shelf (COTS) units to the WWT-Bio system at the Fort Leonard Wood waste water treatment facility. The COTS (**Figure 7**) system provided data to SLB STO-D to evaluate the WWT-Bio and the 1000-person camp demonstration assessed the benefit of WATERMON information for WWT-Bio operation.

Technical Point of Contact: Lisa Neuendorff, lisa.k.neuendorff.civ@mail.mil, 586-282-4161.

Figure 7: Commercial Approximation of a WATERMON

2.4 Waste Water Treatment-Biological (WWT-Bio)

The WWT-Bio **(Figure 8**) is a stand-alone biological-based system designed to provide waste water treatment capabilities at contingency bases to reduce wastewater hauling. Treatment of wastewater to meet EPA secondary treatment standards will allow for safe onsite discharge and a 50%+ reduction in wastewater hauling requirements. The system provides a new capability that is designed to adapt to widely varying load conditions and provide rapid start-up. It reduces the logistical burden and health risk to the Warfighter.

System characteristics are:

- Size – Pack out volume of ≤ 416 ft³ (Tricon).
- Weight – ≤7,110 lb.
- Manpower – Minimal, automatic control and operation.

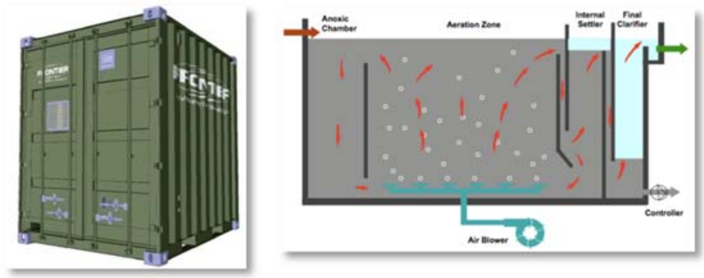

Figure 8: WWT-Bio System (Right) and Internal System Process (Left)

Technical Point of Contact: Lateefah C. Brooks, lateefah.c.brooks.civ@mail.mil, 586-282-6587.

2.5 PowerShade (PSHADE) Cost Reduction

The PSHADE (**Figure 9**) is a fabric structure with built-in photovoltaic (PV) array that is designed to shade and provide power to tents, rigid-wall shelters, vehicles, etc.

Figure 9: PSHADE over a TEMPER Tent

The congressionally funded PSHADE program intends to reduce cost and improve PV component parts by focusing on extending durability of the base textile materials, reducing manufacturing cost of components via optimized design and manufacturing processes, and increasing the efficiency of the Balance of System (BOS) by implementation of grid tie capability/high efficiency power electronics. These combined efforts hold promise to provide a higher electrical generating capability at a lower weight and cost, offering a more attractive alternative/supplement to traditional fuel fired electrical generators. Other features of the effort are to:

- Reduce initial procurement cost by 20% (Threshold (T)) to 30% (Objective (O)) for a given PV generation capability.
- Increase peak kW output of a given size PSHADE by 10% (T) to 20% (O).
- Increase lifespan from a 3-year specification to 10 years.
- Reduce deployment effort required for erection by reduction of weight of structural components.

Technical Point of Contact: Steven R. Tucker, steven.r.tucker10.civ@mail.mil, 508-233-6962.

2.6 Energy Informed Operations - Central (EIO-C)

The EIO-C (**Figure 10**) is an interface standard for an autonomous tactical microgrid architecture from 15 to 300kW that supports Army Contingency Basing power availability and reliability, while reducing generator fuel usage and maintenance. Its purpose is to develop, implement, and support an intelligent power system interface standard and associated applications that allow optimization of power and energy resources based on mission objectives.

Figure 10: EIO Concept

The EIO-C microgrid features open, standardized interfaces for communication and power interconnects with advanced control hardware and software that includes smart generation sources, robust intelligent distribution boxes, and potential for future expansion into components such as power inverters, controllers for renewable source input, and energy storage devices. It also includes an EIO-C microgrid application providing enhanced grid awareness, analytics, and control of power resources.

Other features of the EIO-C include:

- Improved efficiency in OE to reduce cost and logistics burden of fuel resupply.
- Ability to prioritize and utilize power resources according to mission needs enabling commanders with information and flexibility to complete the mission in a resource constrained environment.
- More reliable and resilient energy network to ensure the availability of power across the battlespace.

Technical Point of Contact: Marnie Bailey, marnie.e.bailey.civ@mail.mil, 443-395-4793.

2.7 Deployable Metering and Monitoring System (DMMS)

The DMMS (**Figure 11, Figure 12,** and **Figure 13**) is a multicomponent electronic system for monitoring, data acquisition, analysis, and information dissemination of base camp sustainment/logistics elements, e.g., energy, fuel, water, waste, etc.

Figure 11: DIACAP Approved Wireless Metering Solution Interfacing with a Generator Set

The three components of DMMS are:

- DIACAP[3] Approved Wireless Metering Solution. A suite of electrical meters and sensors to monitor base camp functional elements. The Wireless Metering Solution box:
  - Provides in-line advanced electrical meters and sensors for monitoring Forward Operating Base (FOB)/Combat Outpost (COP) supply and demand side power.
  - Monitors fuel and temperature status.
  - Meters and sensors are enclosed in portable transit cases to facilitate rapid deployment and set-up, i.e., “plug and play”.
  - Connects to open architecture dashboard.
- Contingency Base-Energy Management System (CB-EMS). A computerized dashboard for data acquisition and analysis of base camps sustainment/logistics elements. The CB-EMS:
  - Provides a dashboard to facilitate informed decision making.
  - Allows for control over end uses to help manage base camp energy consumption.
  - Enables data analysis that provides a means for data collection and visualization.
  - Provides reports for individual meters, systems, buildings, camps or multiple camps.
  - Transmits data to OE data repository.

Figure 12: CB-EMS Dashboard

- Wide Area Visualization Environment (WAVE). A computerized visualization tool that:
  - Provides a cyber-secure web portal for review of base camp data at Regional, Command, and Theater levels.
  - Integrates data from multiple systems for monitoring, management, and planning of operational energy use.
  - Displays data analytics and location information in customizable views using the toolset analytical and GIS capabilities.
  - Provides automated data transfer using standardized data formats on a secure NIPRNET connection.

Figure 13: WAVE Visualization Tool

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2.8 Hybrid Power Trailer (HPT)

The HPT (**Figure 14**) is an electrical power generation system that couples a standard Army 15 kW tactical quiet generator (TQG) with an 80 kW-hr lithium ion battery mounted on a trailer. The system decreases generator run time, reduces fuel consumption, enables silent operation, and provides power redundancy for military applications.

Figure 14: Hybrid Power Trailer

---

[3] DoD Information Assurance Certification and Accreditation Process (DIACAP)

Important characteristics of the HPT are:

- Reduced fuel consumption by 80% (54 gal/day (gpd) down to 11 gpd) during spring and summer testing at ERDC Forward Operating Base Laboratory (E-FOB-L) in Champaign, IL.
- Provided 28 hours of silent operation at low loads (< 2 kW).

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2.9 Structural Insulated Panel Hut (SIP-Hut)

Figure 15: SIP-Hut

The SIP-Hut (**Figure 15**) is an alternative to semi-permanent barracks (commonly known as Barrack Huts or B-Huts). The SIP-Huts are constructed of pre-manufactured structural insulated panels that have a high insulating value (both thermal and acoustic), and provide for quick assembly/disassembly. The SIP-Hut takes one-third the time to construct and is twice as energy efficient as the current B-Huts.

Important features of the SIP-Hut are:

- Potential 80% reduction in energy consumption compared to non-insulated B-Hut.
- 50-60% reduction in squad-hours construction time compared to B-Hut (not including roof) with non-skilled labor.

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3. SUPPORT SYSTEMS, ARCHITECTURE, AND INSTRUMENTATION

The systems employed during the demo can be categorized in two ways. The first is the most obvious, that being the SLB-STO-D candidate technologies selected by the TMIT for inclusion in the demo, but data were also considered and collected on some key baseline systems that the MSAT will use for comparison to determine savings in fuel, water, and waste. This chapter includes descriptions of these baseline and support systems, as well as the architectures for all systems, and descriptions of the data collection instrumentation employed in this demonstration.

3.1 Baseline and Other Demonstration Support Systems

This demonstration employed a few of the permanent CBITEC systems, including the billeting shelters and environmental control units (ECU). Some of these systems are included in the SLB-STO-D baseline and some are surrogates employed to execute the demo.

3.1.1 B-Hut

The CBITEC facility includes 14 B-Huts, which are 16 ft x 32 ft wood frame, plywood sheathed buildings whose standard design was adapted from the Army Facilities Component System (AFCS). This standard design is used to ensure comparability of data collected during their use. The B-Huts can be used for a variety of technology demonstrations, to include assessment of lightweight liners and coatings, performance of ECUs, and assessment of troop power demand. The B-Huts are heated and/or cooled with an ECU or an Improved ECU (IECU). Two of the site B-Huts are unimproved and serve as controls while the remainder are available for experimentation. Each building can be individually metered and monitored for a variety of evaluation data to include power demand and interior temperature. Each B-Hut at CBITEC serves as troop billeting for up to 20 Soldiers in training. This provides assessments under realistic Soldier occupancy and operational demands for not only the B-Huts, but other base camp systems used by the Soldiers. **Figure 16** shows two B-Huts at CBITEC.

Figure 16: Typical B-Hut

Table 2 was developed by Army Materiel Systems Analysis Agency/Activity (AMSAA) and characterizes each B-Hut at CBITEC.

Table 2: B-Hut Characteristics

Assets			Operational	Technology Configurations			
Shelter ID	Block #	Power Source	Use	Treatment	Location	Type	ECU
1A	Block 5	EIO Grid 1	Soldiers	SUPER THERM	Exterior	Resin coating	IECU
1B	Block 5	EIO Grid 1	Soldiers	Tent Like liner	Interior	NOT INSTALLED (control?)	IECU
1C	Block 5	EIO Grid 1	Soldiers	None	N/A	Control C	IECU
1D	Block 5	EIO Grid 1	Soldiers	White Paint	Exterior	White paint all surfaces	IECU
1E	Block 5	EIO Grid 1	Vacant	Thermal Control Membrane	Interior	Multi-layer thin foil membrane	IECU
1F	Block 5	EIO Grid 1	Vacant	Fi-Foil Radiant Shield	Interior	Two foil layers laminated to polyethlene	IECU
1G	Block 5	EIO Grid 1	Vacant	None	N/A	Control G	F100
1H	Block 5	EIO Grid 1	Soldiers TOC	LO-MIT-I	Exterior	low emissivity coating	IECU
2A	Block 4	60kW 1	Vacant	Desert Shade	Exterior	Shade	F100
2B	Block 4	60kW 1	Vacant	None	N/A	None	F100
2D	Block 4	60kW 1	Admin	None	N/A	None	F100
2E	Block 4	60kW 1	DMC	None	N/A	None	F100
2G	Block 4	60kW 1	Vacant	Forest Shade	Exterior	Shade	F100
2H	Block 4	60kW 1	Vacant	None	N/A	None	F100

3.1.2 F100 60K ECU

Some of the CBITEC B-Huts were cooled and heated with the F100-60K ECU. Selected B-Huts have a dedicated ECU installed on the pad outside the hut and are connected to the hut with 16 in ducts. All ECUs were powered from EIO-C grid. The ECU operating modes are OFF/COOL/HEAT/VENT. Internal shelter temperature was roughly controlled with a manually adjustable thermostat. **Figure 17** shows the F100 ECU.

Figure 17: F100 60K ECU

3.1.3 Improved ECU

Some of the CBITEC B-Huts were cooled and heated with the IECU. Like the F100, the IECU is installed on the pad outside the hut and is connected to the hut with 16-in ducts. Again, like the F100s, all IECUs were powered from EIO-C grid. Internal shelter temperature was roughly controlled with a manually adjustable potentiometer. Error! Reference source not found. shows the IECU.

Figure 18: IECU

3.1.4 Tent, Extendable, Modular, Personnel (TEMPER) Air Supported Shelter

The CBITEC erected one 32-ft TEMPER Air Supported shelter to house static displays and provide a briefing area. The Air Supported floor space is 20 x 32 ft. There are four identical 10-in diameter, 20-ft clear-span supports. The interior of the shelter contains two rows of overhead lights, two electrical wiring harnesses, and the air distribution plenum. An F100 ECU provided heat and air conditioning as required. **Figure 19** is a picture of the display tent with the PowerShade over the shelter.

Figure 19: TEMPER Air Supported Shelter with PowerShade

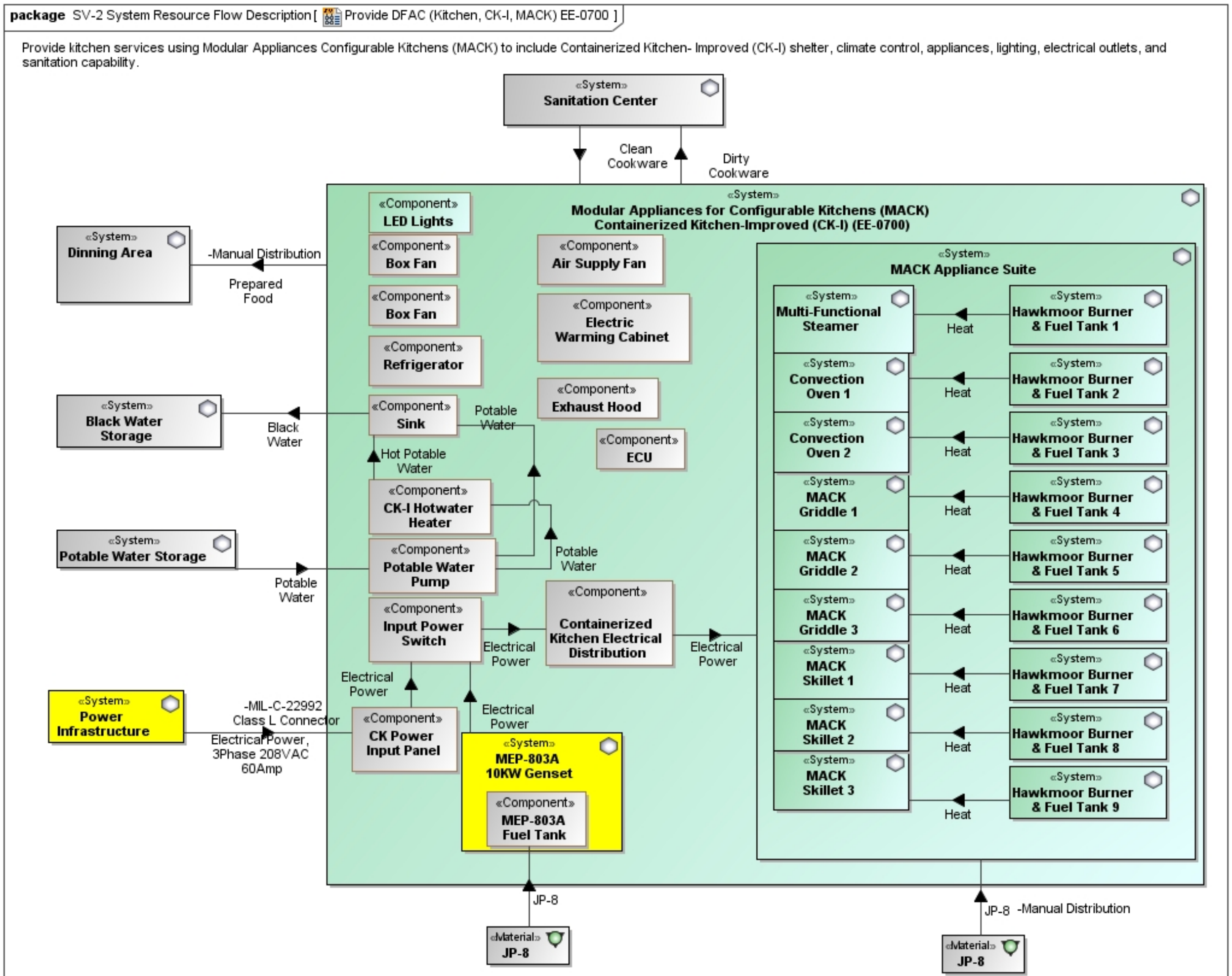
3.2 System Architectures

Top-level views of the venue are shown in **Figure 20** and **Figure 21**.

Figure 20: Overall CBITEC Architecture

Figure 21: Water Treatment Plant Architecture

System architectural views (SV-2s) for each technology were developed by the SEIT and are included as **Figures 22** through **30**, respectively.



Typical Operational Activities: Operators would first turn on the kitchen lights, then disconnect the empty fuel tanks in each appliance -- no tools are required for this -- and carry them to a suitable fueling location for fueling once per day. Reconnect is the reverse of disconnect. Once reconnected, the operators would turn on the burner switches and set the thermostats. At this time they may turn on the exhaust hood fan. They would then perform cooking duties as in any other mobile kitchen.

Typical Maintenance Activities: We do not anticipate any tuning or adjustment will be required. The only filter is the fuel filter. The only waste generated will be the old fuel filter.Typical Monitoring Activities: Aside from noticing that an appliance has ceased to create heat, the operator would watch for lights on the appliance front that indicate a malfunction. Should there be such an indication, the operator would look to the additional indicator lights on the burner. The operator would consult documentation describing failure modes and corrective actions, then act accordingly. For instance, options are to turn the burner off then on, press the lockout reset button, press the fuel pump purge button, or inspect the fuse. Replacing the entire burner with a spare is also an option; this takes about one minute.

Electric Power flows internal to
CK-I not shown for clarity

LEGEND

Technology | Legacy Equipment or CBITEC Facility Or Equipment | Power Infrastructure | Each Hawkmoor Burner consumes 0.33 gl/hr | Nominal Interior Temperature 68F to 78F | CK-I MACK Appliances utilize prototype Hawkmoor Burners.

Figure 22: SV-2 MACK – Provide Kitchen

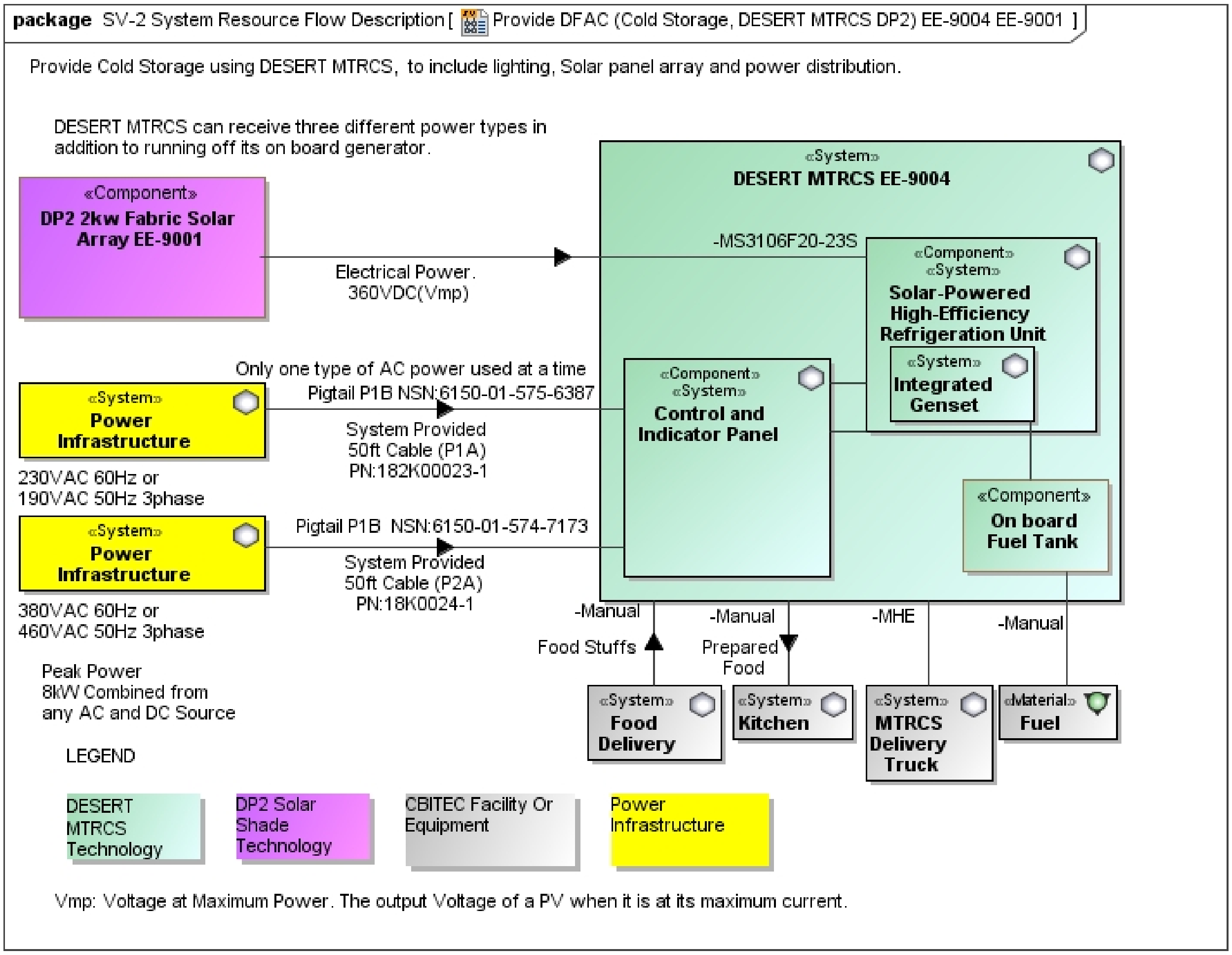


Figure 23: SV-2 DESERT – Provide DFAC

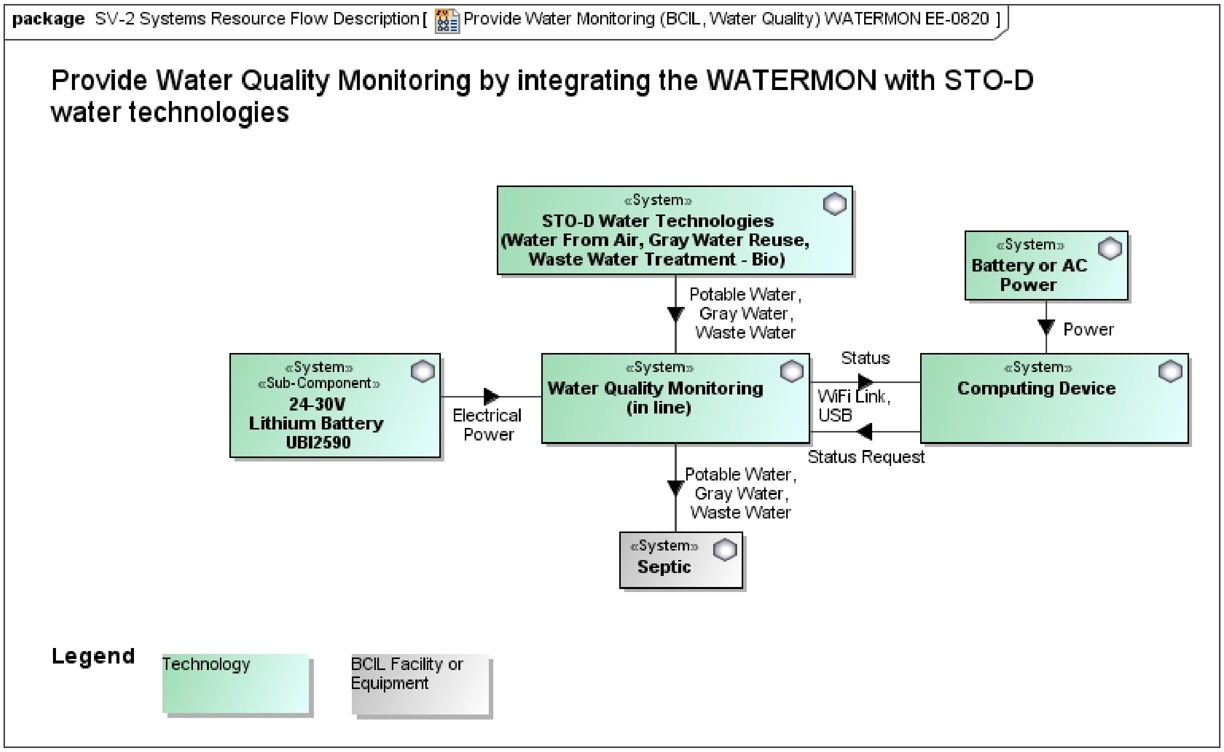


Figure 24: SV-2 WATERMON – Provide Water Quality Monitoring

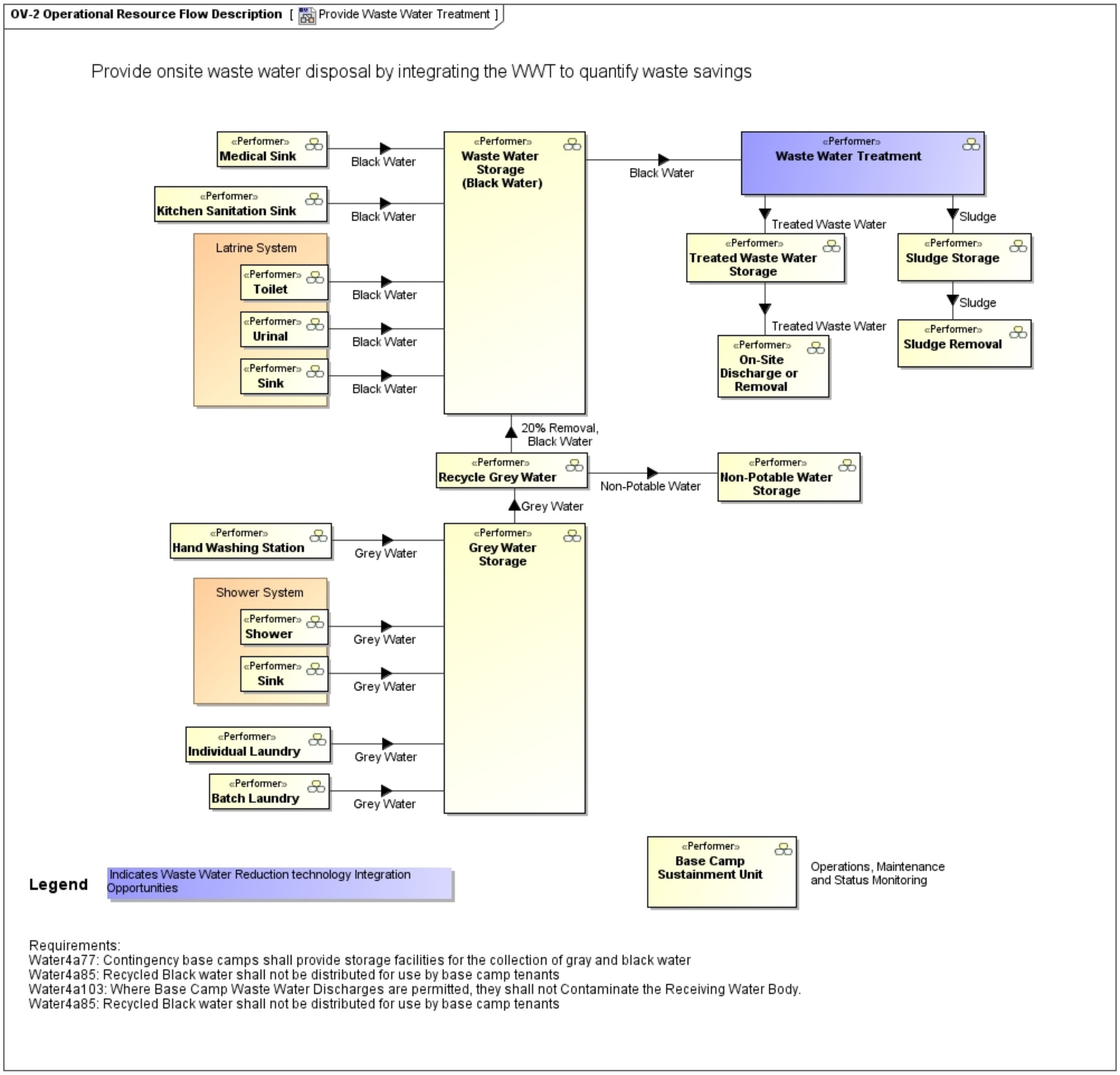


Figure 25: SV-2 WWT-Bio – Provide Waste Water Treatment

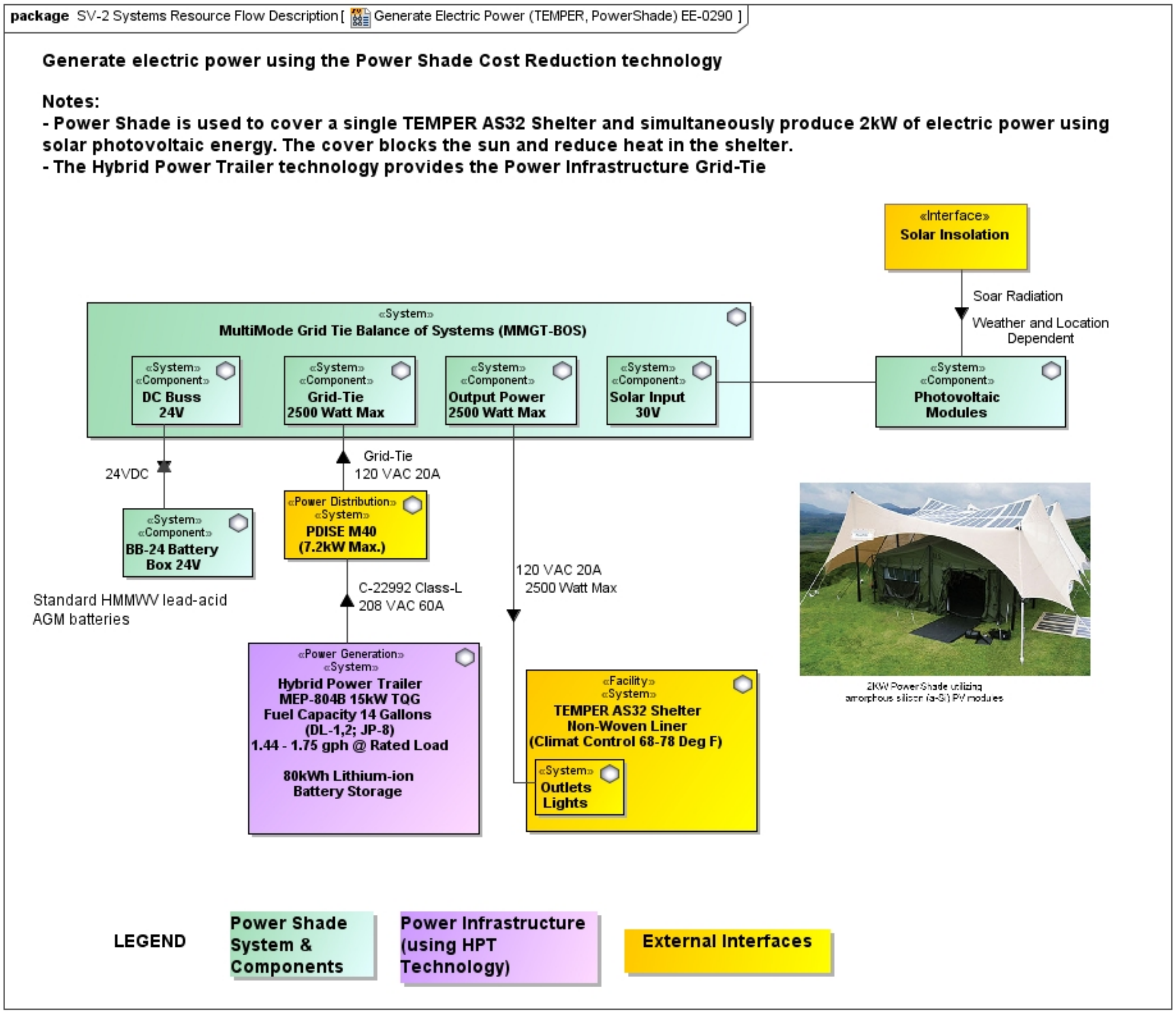


Figure 26: SV-2 PSHADE – Provide Electric Power

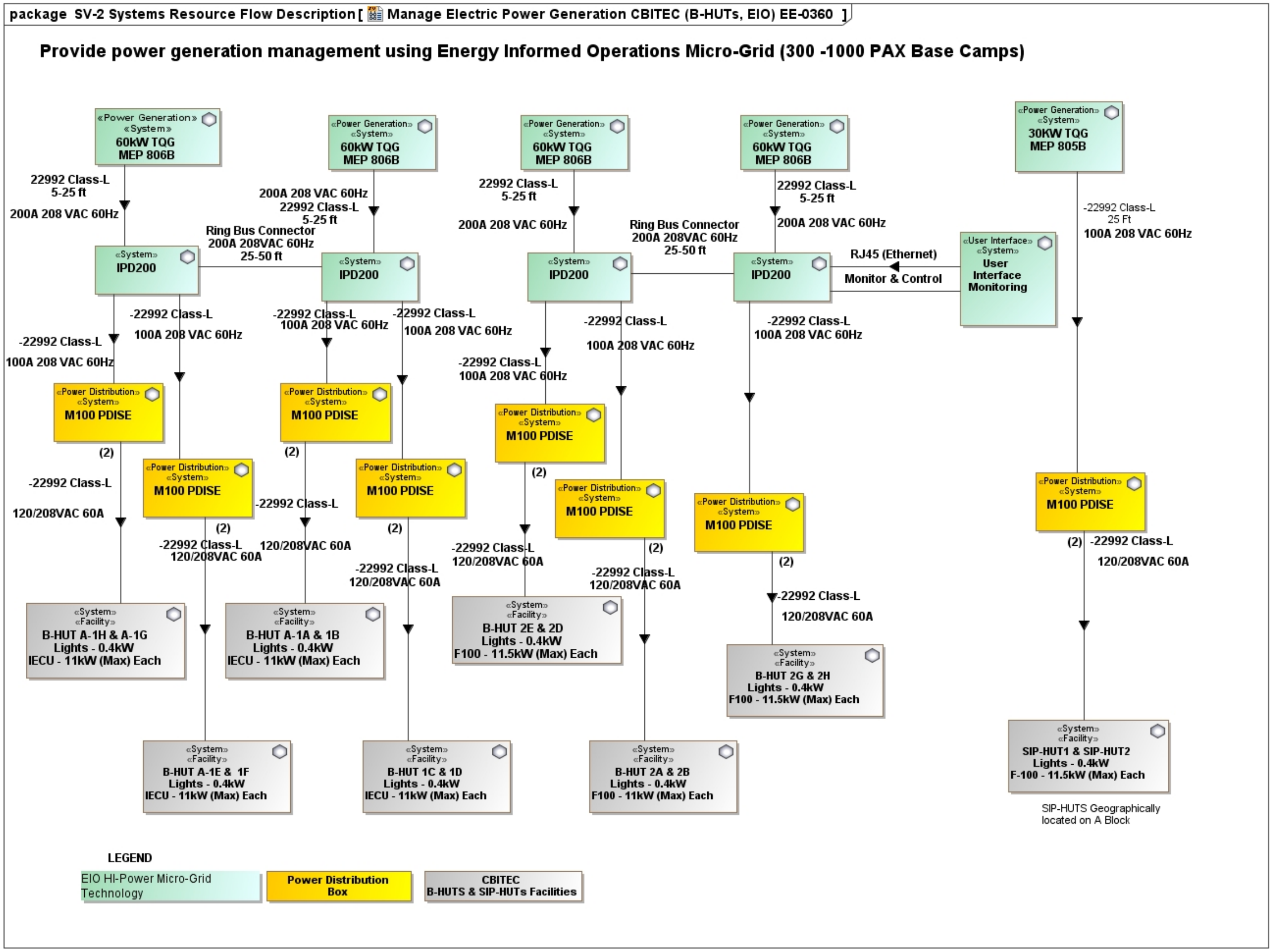


Figure 27: SV-2 EIO-C – Manage Electric Power

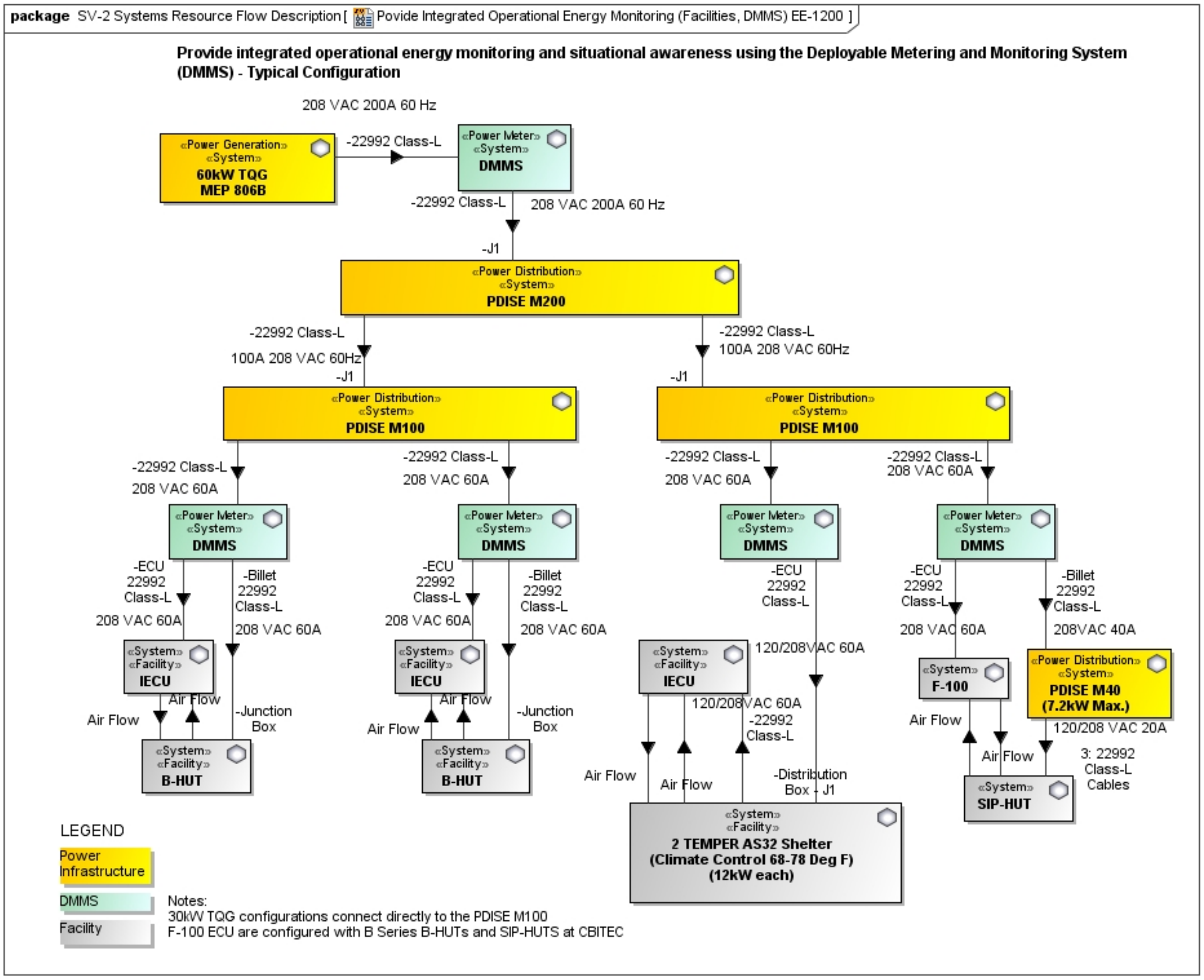


Figure 28: SV-2 DMMS – Provide Energy Monitoring

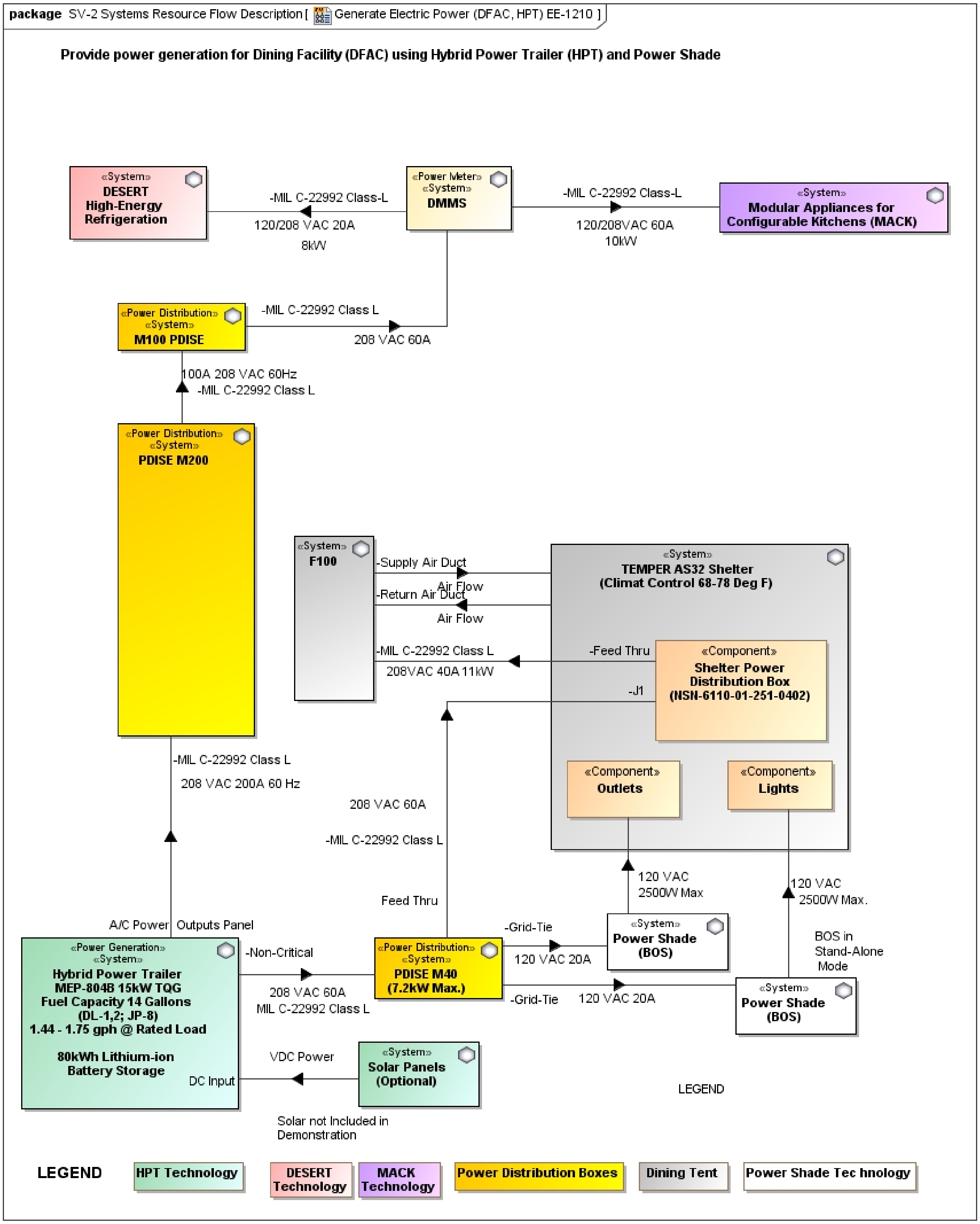


Figure 29: SV-2 HPT – Generate Electric Power

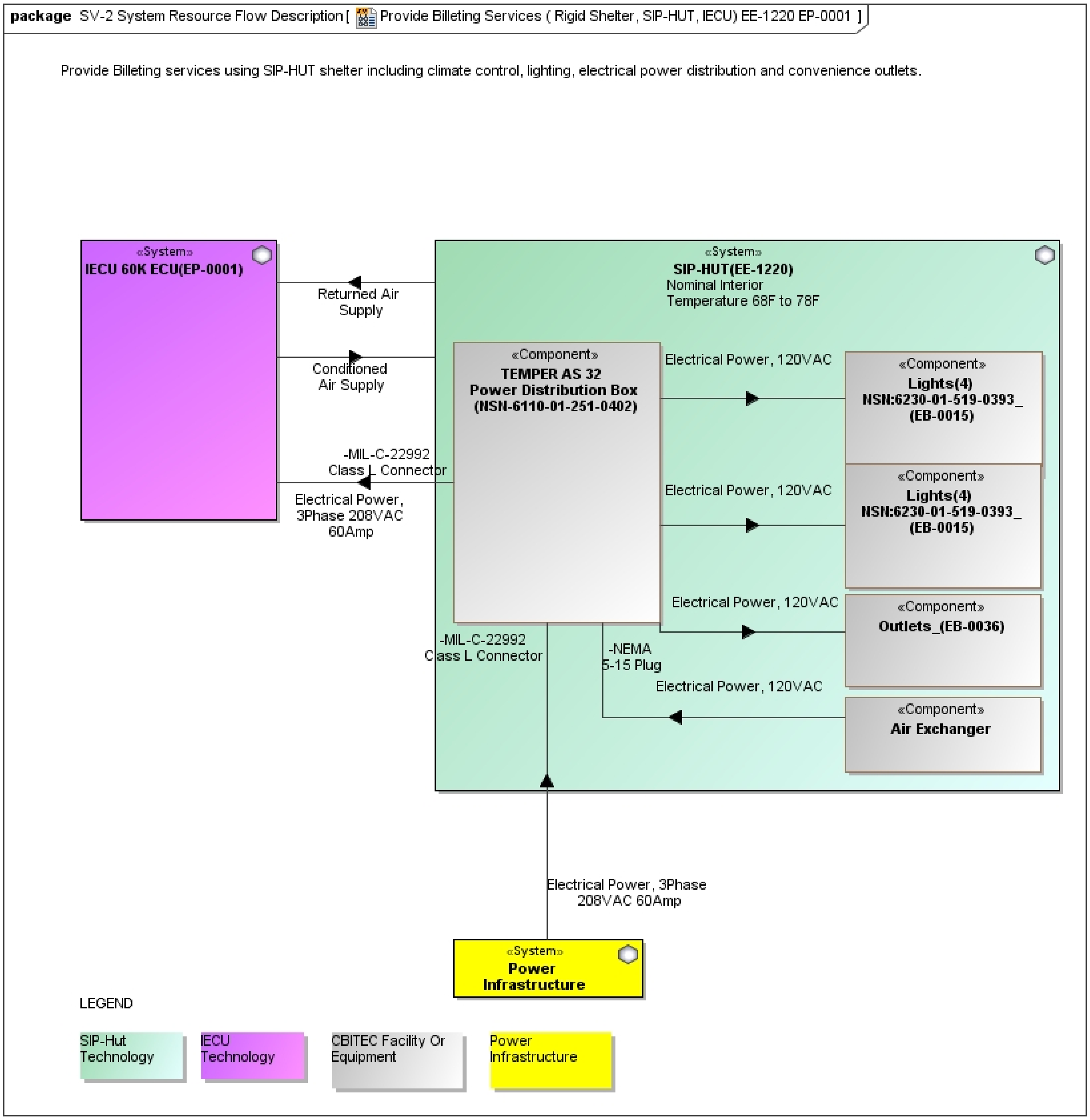


Figure 30: SV-2 SIP-Hut – Provide Billeting

3.3 Instrumentation

To meet **Objective 1** (*Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and can be used to support trade-offs and engineering decisions*) each of the technologies were instrumented. The following sections describe how each technology was instrumented. Additional detail on instrumentation is located in **ANNEX A**.

Weather data was collected with two different weather stations. During the period 13-18 April CBITEC's HOBO weather station located in the maintenance yard, seen in **Figure 31**, was used

to collect weather data. During the day on 18 April EDVT's Davis weather station, seen in **Figure 32**, was installed and configured next to the MACK. Starting 19 April through the end of data collection on 25 April, EDVT's Davis weather station was used to collect weather data. For solar radiation, an Apogee Instruments pyranometer model SP-214 positioned on top of the PSHADE is included in the weather data.

Figure 31: CBITEC's HOBO Weather Station

Figure 32: EDVT's Davis Weather Station

3.3.1 MACK Instrumentation

The MACK was instrumented to collect power, temperature, sound, humidity, and water data. In addition, a scale was used to measure fuel consumed. **Table 3** shows the Data Source Matrix (DSM) for required MACK data elements, including the sensor type for each element.

Table 3: MACK Data Source Matrix

Data Element	Unit	Scale	Collection Method	Sample Period	Sensor Type (if used)
Kitchen Temperature Location 1	°F	0.1 °F	Electronic (TC)	24 hours	ProSense RTD TTD25N-20-0300F-H
Kitchen Temperature Location 2	°F	0.1 °F	Electronic (TC)	24 hours	ProSense RTD TTD25N-20-0300F-H
Kitchen Temperature Location 3	°F	0.1 °F	Electronic (TC)	24 hours	ProSense RTD TTD25N-20-0300F-H
Kitchen Temperature Location 4	°F	0.1 °F	Electronic (TC)	24 hours	ProSense RTD TTD25N-20-0300F-H
Energy Consumed by Left Oven	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Left Oven	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Left Oven	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Right Oven	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Right Oven	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Right Oven	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Left Skillet	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Left Skillet	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Left Skillet	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Middle Skillet	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Middle Skillet	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Middle Skillet	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Right Skillet	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Right Skillet	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Right Skillet	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Left Griddle	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Left Griddle	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Left Griddle	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Total Energy Consumed by Middle Griddle	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Middle Griddle	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Right Griddle	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Right Griddle	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Right Griddle	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Energy Consumed by Serving Line	kWh		Electronic	24 hours	Dent Meter
Total Energy Consumed by Serving Line	kWh		Electronic	24 hours	Dent Meter
Fuel Consumed by Serving Line	lb	.1 lb	Manual	24 hours	Manual DC Form and Ohaus Scale
Total Energy Consumed by Kitchen	kWh		Electronic	24 hours	DMMS 60A
Energy consumed by other appliances	kWh				
Kitchen Prep Sink	gal		Electronic	24 hours	Badger Meter

Total power to the MACK was measured by a 60-ampere DMMS box. The rest of the instrumentation was wired to an Analog to Digital (A2D) box. **Figure 33** shows the DMMS and A2D boxes.

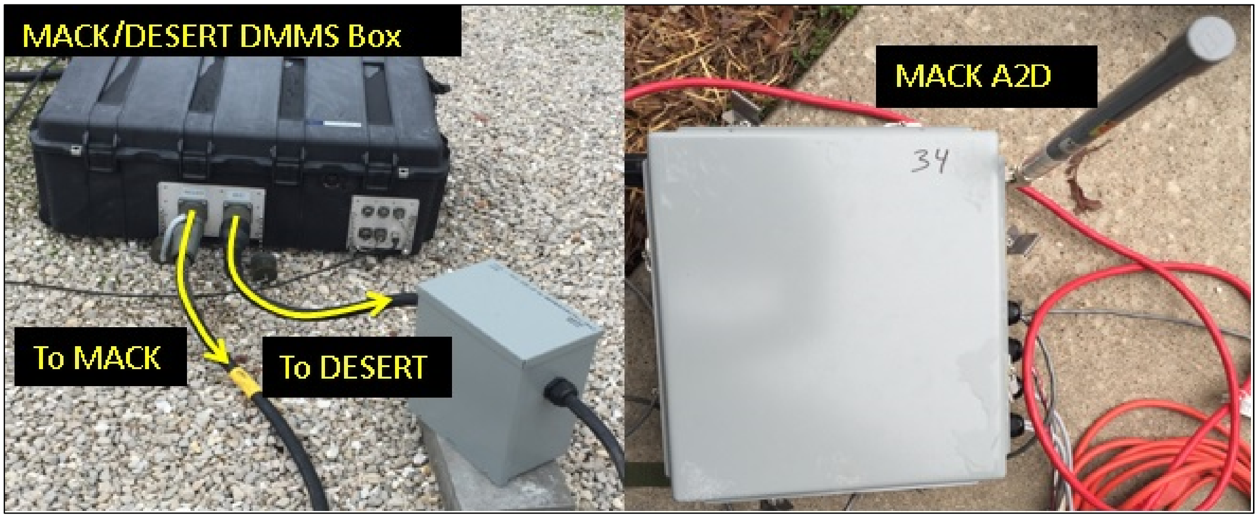


Figure 33: MACK DMMS and A2D boxes

Four ProSense Resistance Temperature Detectors (RTDs), model TTD25N-20-0300F-H, were used to record the temperature in various locations in the MACK. **Figure 34** shows their locations near the ovens, the serving line and food warmer, the griddles, and the skillets.

Figure 34: Temperature Sensors in the MACK

DENT PowerScouts **(Figure 35)** were used for measuring the power usage of the MACK appliances in detail. One was used for the skillets, one for the griddles, and one for the ovens. The meters were secured above light fixtures near the appliances they served. The power meters sent data over the B-Mesh Radio network to the DMMS server.

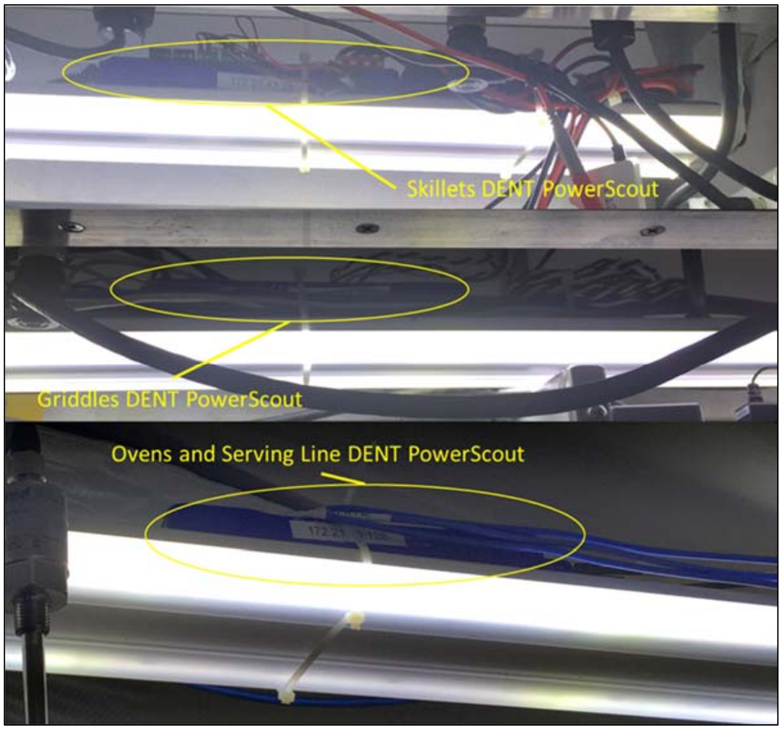


Figure 35: PowerScout Sensors in the MACK

AC voltage and current probes were attached to the power lines for the MACK appliances and fed into the DENT PowerScouts for power metering. **Figure 36** shows the probes for the griddles, skillets/serving line, and ovens.

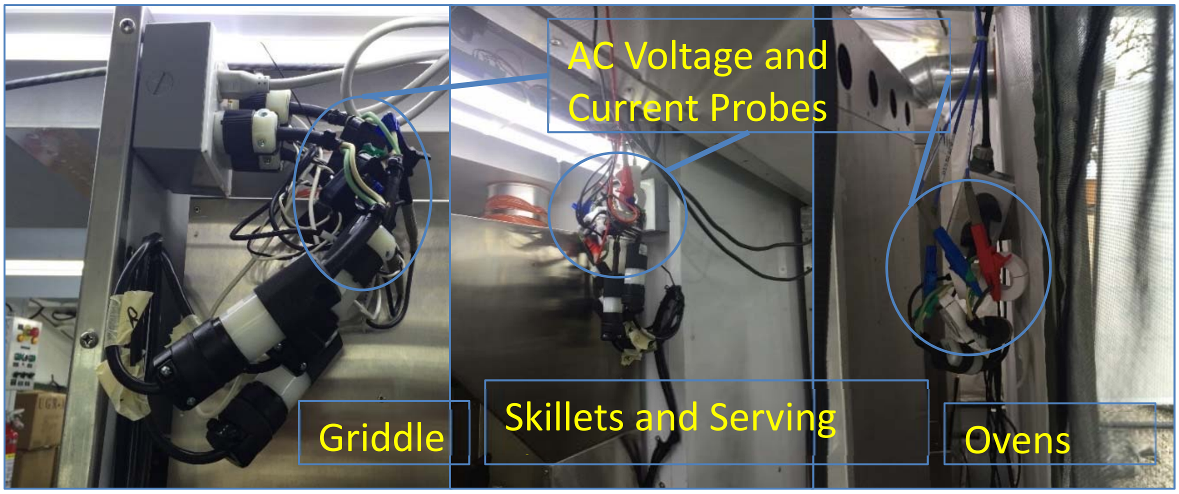


Figure 36: Probes for MACK Appliances

An Extech Sound Level Meter 9WTE8 (**Figure 37**) was used for measuring the sound levels inside the MACK. It was installed above the griddles.

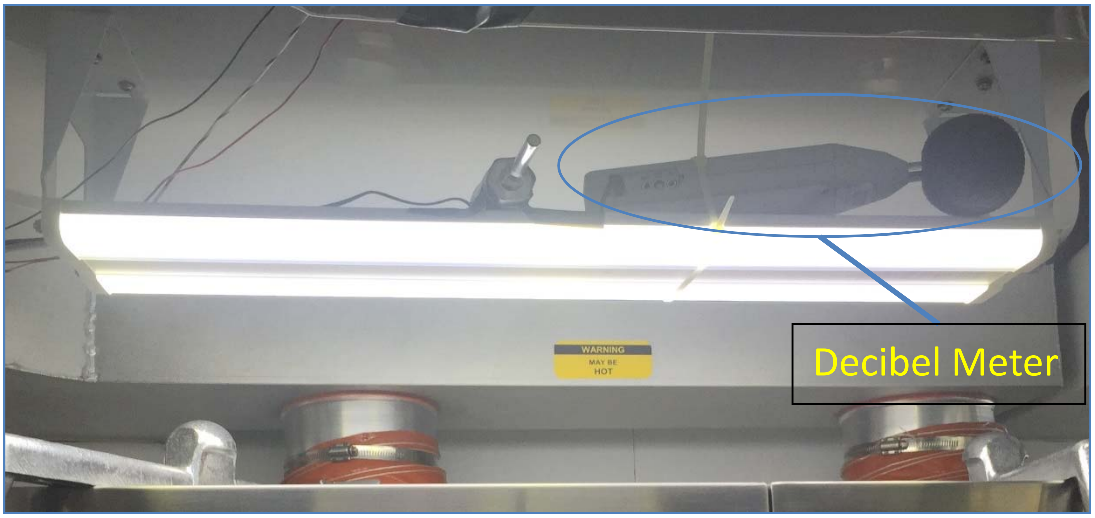


Figure 37: Decibel Meter

A humidity sensor, model HM1500LF, **(Figure 38)** was hung from the vents in the ceiling of the cooking area to measure the humidity levels inside the MACK.

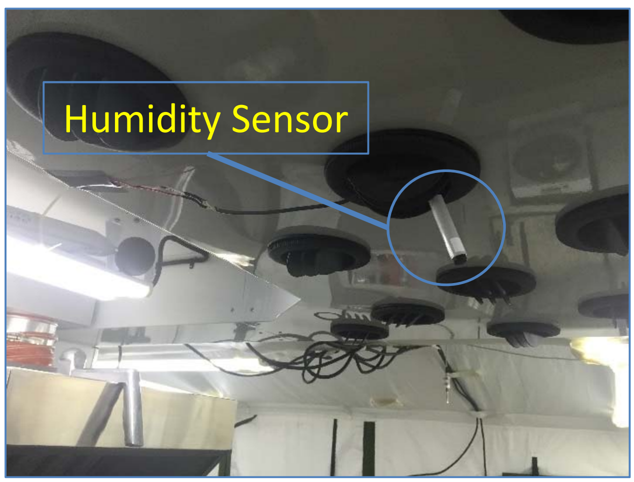


Figure 38: Humidity Sensor

Three Badger flow meters were used to measure the water usage of the MACK. One measured the total flow into the MACK, one measured the usage by the prep sink, and one measured the outflow from the MACK to the Field Sanitation Center (FSC). The Badger meters for the MACK and prep sink are shown in **Figure 39**.

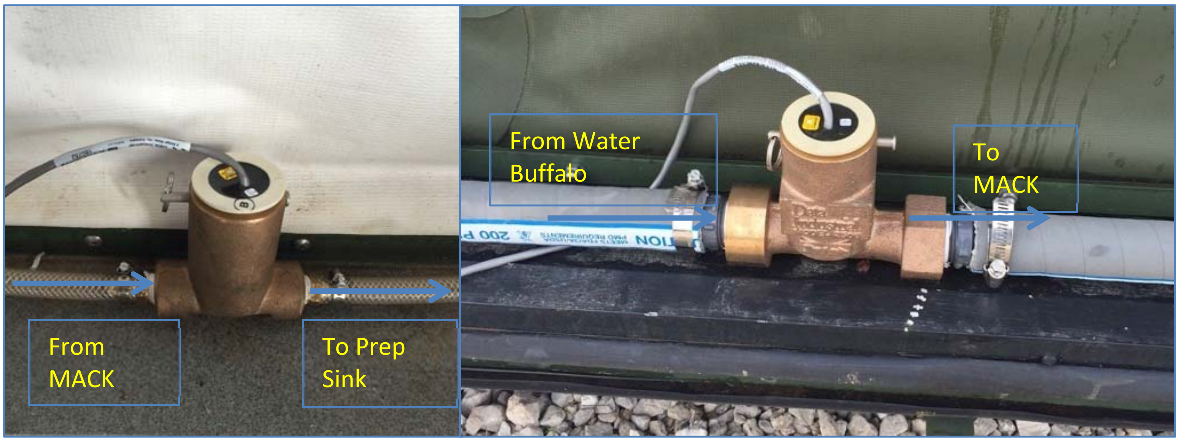


Figure 39: Badger Flowmeters

Jerry cans containing fuel were weighed with an Ohaus scale (**Figure 40**).

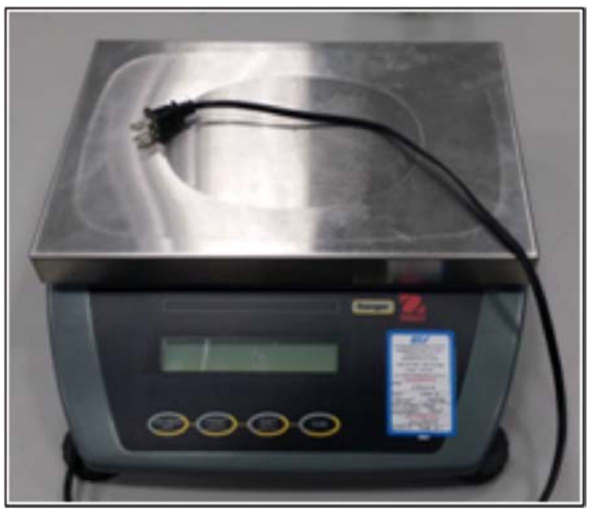


Figure 40: Ohaus Scale for Measuring Fuel Weights

See **ANNEX A** for a complete description of how the sensors were wired to DMMS and A2D to transmit the data.

3.3.2 DESERT Instrumentation

The DESERT was instrumented to collect power, temperature, humidity, door openings and closings, and solar irradiance data.

Table 4 is an extract of the DSM mapping data elements to instruments.

Table 4: DESERT Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
Temperature of Compartment A (front 25%)	°F	0.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Temperature of Compartment B (rear 75%)	°F	0.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Shore Power	kW	10 W	Electronic	Time Series	DMMS 60A
Shore Energy	kwh	10 W	Electronic	Time Series	DMMS 60A
Condenser Air Temp In	°F	0.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Internal Humidity of Compartment A (front 25%)	%	1%	Electronic (HS)	Time Series	HM1500LF Humidity Meter
Internal Humidity of Compartment B (rear 75%)	%	1%	Electronic (HS)	Time Series	HM1500LF Humidity Meter
Int. Air Temp. Return - 1st Evap.	°F		Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Int. Air Temp. Supply - 1st Evap.	°F		Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Int. Air Temp. Supply - 2nd Evap.	°F		Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Internal Air Temp. - Btm-Rt-Rear	°F	0.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Door Open/Close - Rear	event	N/A	Electronic	Time Ordered List	Seco-Larm Mag Sensor
Door Open - Rear	duration	HH:MM:SS	Electronic	Time Ordered List	Seco-Larm Mag Sensor
Door Open/Close - Side	event	N/A	Electronic	Time Ordered List	Seco-Larm Mag Sensor
Door Open - Side	duration	HH:MM:SS	Electronic	Time Ordered List	Seco-Larm Mag Sensor

A 60-ampere DMMS box (**Figure 41**) was used to measure the power usage of the DESERT. The DESERT's power data was output to a DMMS box that was shared with the MACK. The other instruments were wired into a separate A2D box, which transmitted the data for storage.

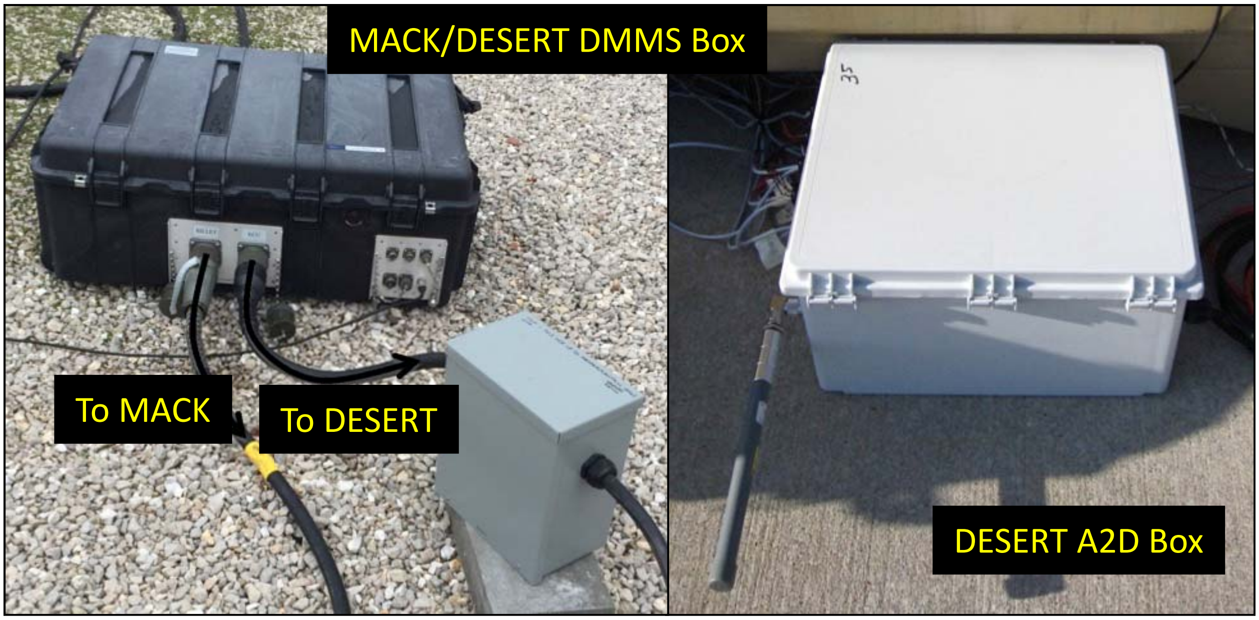


Figure 41: DMMS Box for DESERT

Seven ProSense RTDs were used to measure the temperatures in various locations in the DESERT. They were located in the airflow paths of the two evaporators, in the corners of the front and back of the DESERT, and near the compressor on the outside of the DESERT. The RTDs are shown in **Figure 42**.

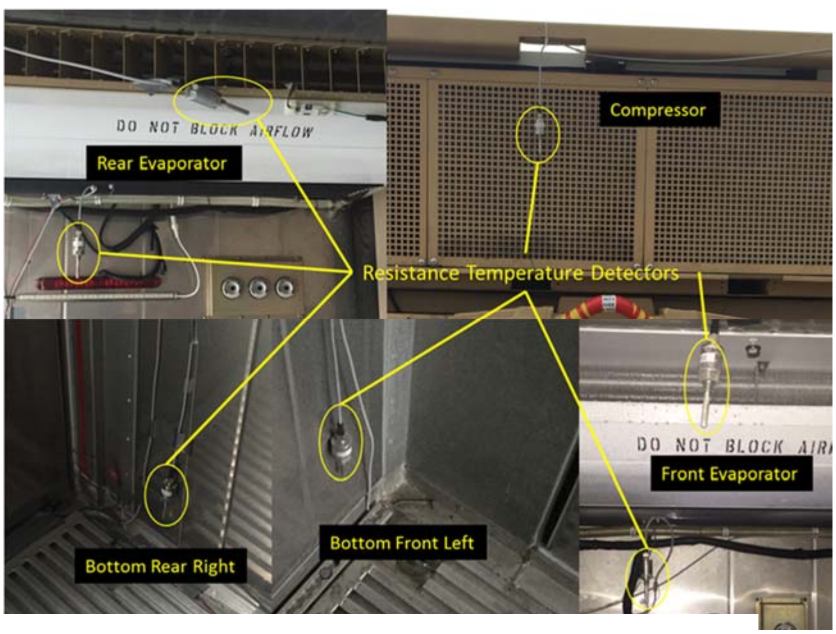


Figure 42: RTD Locations in DESERT

Two HM1500F humidity sensors were affixed, one to each of the evaporator supply vents (**Figure 43**).

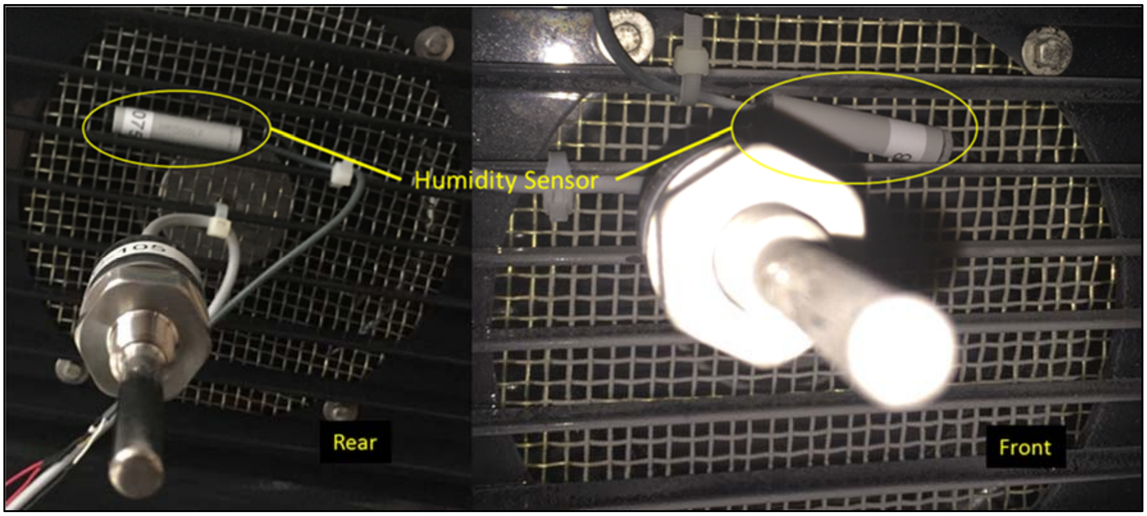


Figure 43: Humidity Sensors in the DESERT

Two Apogee Instrument pyranometers, model SP-214, (**Figure 44**) were used to measure the solar irradiance in the open and under the PV array shade in order to determine the effectiveness of the shade. The shaded pyranometer was suspended just under the middle of the shade and the unshaded pyranometer was installed on top of the DESERT.

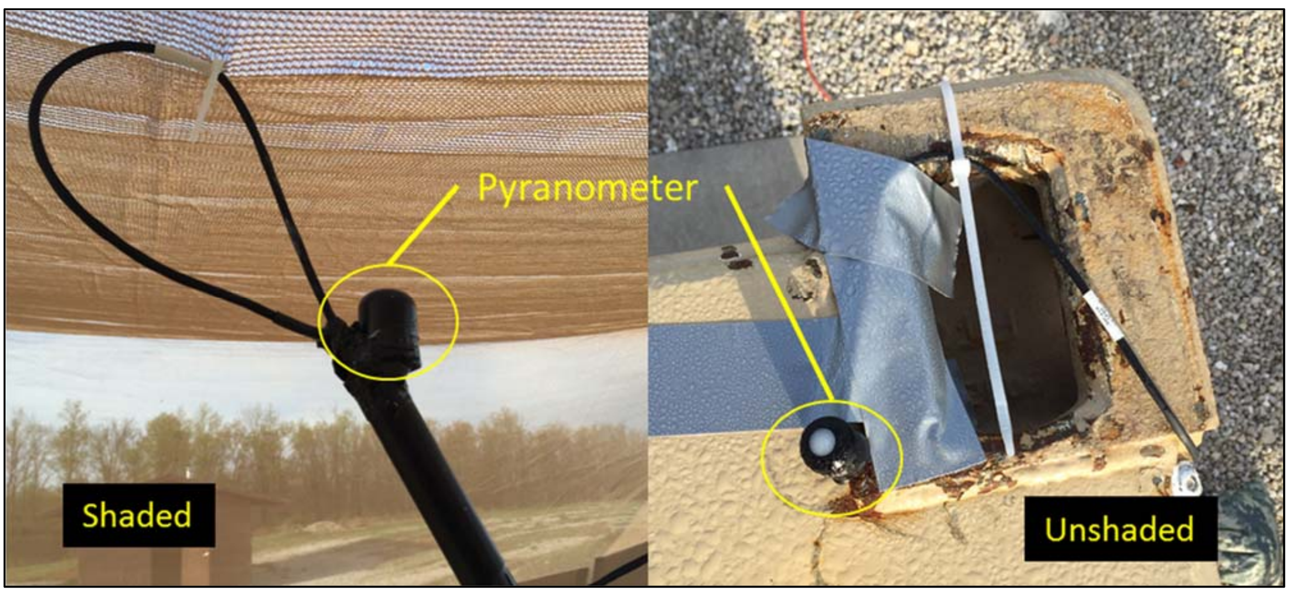


Figure 44: Pyranometers for DESERT

A Seco-Larm door sensor, model SM-205Q, was affixed to each of the three doors on the DESERT, which recorded when the doors were open or closed (**Figure 45**).

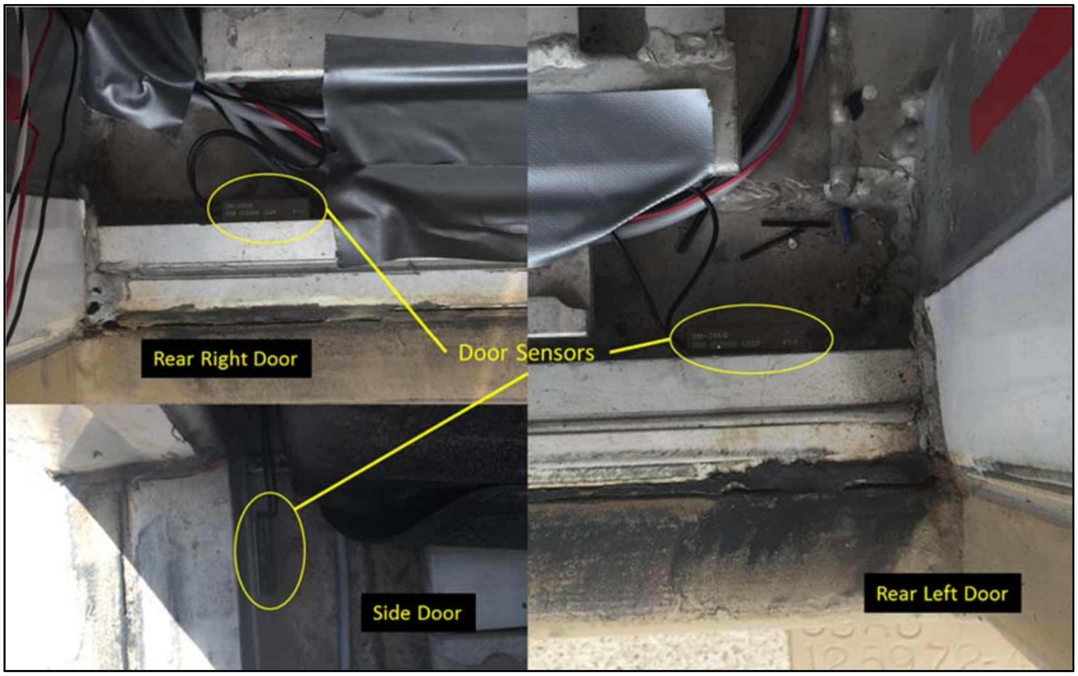


Figure 45: Door Sensors for DESERT

The DC voltage transducer, model MAG-DVT-1000-420, and current transducer, model DCT100-42-24-S, for the DESERT and PV Array were used to measure the DC power (**Figure 46**).

Figure 46: DC Voltage and Current Transducers

3.3.3 WATERMON Instrumentation

The WATERMON was not instrumented. It is an instrument itself.

3.3.4 WWT-Bio Instrumentation

The WWT-Bio was instrumented to collect power, temperature, and water data. In addition, a scale was used to measure solid waste effluent. **Table 5** is an extract of the DSM mapping data elements to instruments.

Table 5: WWT-Bio Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
Power data	kW		Electronic	Time Series	Dent Meter
Energy Consumption	kWh		Electronic	Time Series	Dent Meter
Combined wastewater in (gph)	GPH		Electronic		Onboard Flowmeter - TFX Ultra
Treated water out (gph)	GPH		Electronic		Badger 8250BR1005
Ambient temperature at treated outlet	°F	0.1 °F	Electronic		TC and NI 3212
Treated water out temperature	°F	0.1 °F	Electronic		TC and NI 3212
Waste stream % of total mass inflow	%		Calculation		
Sludge out	Lbs	0.1 lb	Manual		Arlyn Scale

A DENT Elite Pro XC, pictured in **Figure 47**, was used to measure the energy consumption of the WWT-Bio.

Figure 47: DENT Elite Pro XC

An Arlyn scale (**Figure 48**) built by the EDVT was used to measure solid waste effluent.

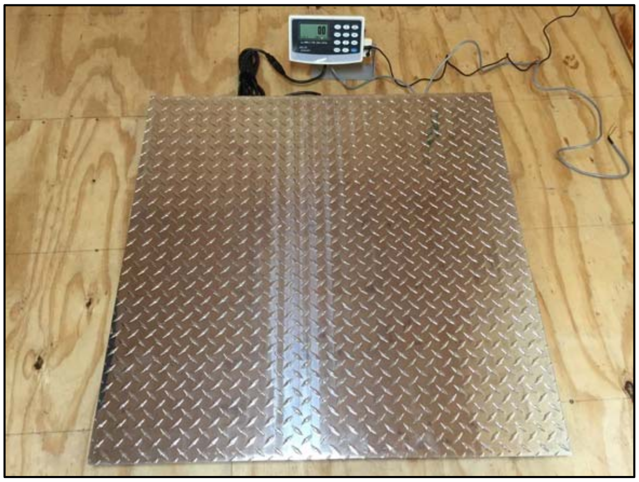


Figure 48: Arlyn Scale

Two thermocouples were used to determine the ambient temperature and the temperature of the treated water at the outlet (**Figure 49**).

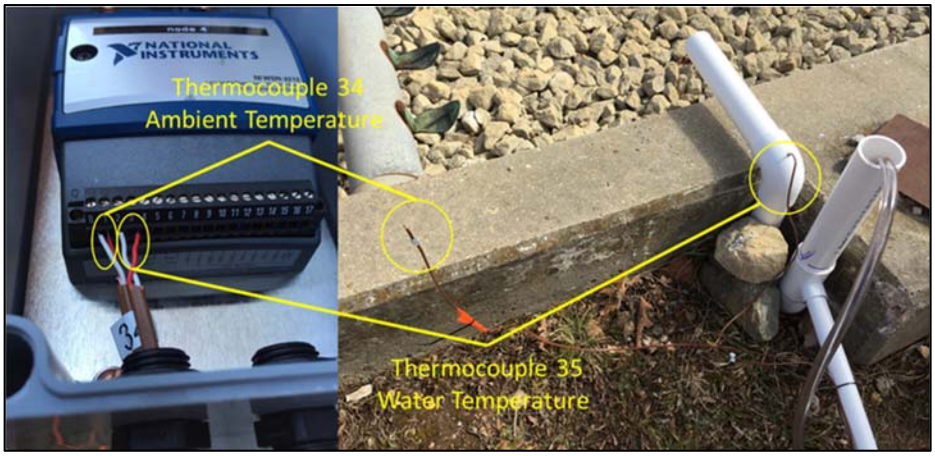


Figure 49: WWT-Bio Thermocouples

3.3.5 PSHADE Instrumentation

The PSHADE was instrumented to collect power, temperature, and solar irradiance data.

Table 6 is an extract of the DSM mapping data elements to instruments.

Table 6: PSHADE Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
Installation Orientation	Direction	1 °F	Manual	Single Measure	Manual DC Form
Ambient temperature	°F	.1 °F	Weather Station	Time Series	Weather Station
Shaded temperatures	°F	.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Unshaded temperatures	°F	.1 °F	Electronic (TC)	Time Series	ProSense RTD TTD25N-20-0300F-H
Shaded Solar irradiance levels	W/m^2		Weather Station	Time Series	Pyranometer SP-214
Unshaded Solar irradiance levels	W/m^2		Weather Station	Time Series	Pyranometer SP-214
Corresponding PV power generation levels	kW	1W	Calculation	Time Series	2 Shark meters
PV Energy generation levels	kWh		Calculation	Time Series	2 Shark meters
PV voltage leg #1	Vdc	.1Vdc	Electronic	Time Series	DC Voltage Kit Fluke VPS220-R with DMMS A-D
PV current leg #1	Adc	.1Adc	Electronic	Time Series	Current Transformer DCT100-42-24-S
PV voltage leg #2	Vdc	.1Vdc	Electronic	Time Series	DC Voltage Kit Fluke VPS220-R with DMMS A-D
PV current leg #2	Adc	ch	Electronic	Time Series	Current Transformer DCT100-42-24-S
PV voltage leg #3	Vdc	.1Vdc	Electronic	Time Series	DC Voltage Kit Fluke VPS220-R with DMMS A-D
PV current leg #3	Adc	.1Adc	Electronic	Time Series	Current Transformer DCT100-42-24-S
PV voltage leg #4	Vdc	.1Vdc	Electronic	Time Series	DC Voltage Kit Fluke VPS220-R with DMMS A-D
PV current leg #4	Adc	.1Adc	Electronic	Time Series	Current Transformer DCT100-42-24-S
246-PSHADE AC Power BOS1 GFCI	kW	1W	Electronic	Time Series	Shark Meter connected to DMMS
246-PSHADE AC Power BOS1 Grid Tie	kW	1W	Electronic	Time Series	Shark Meter connected to DMMS
246-PSHADE AC Power BOS2 GFCI	kW	1W	Electronic	Time Series	Shark Meter connected to DMMS
246-PSHADE AC Power BOS2 Grid Tie	kW	1W	Electronic	Time Series	Shark Meter connected to DMMS
Correlated identification of electrical loads	W	1W	Manual	List of load elements	Manual DC Form

Each BOS had one Shark Meter to measure AC power (**Figure 50**).

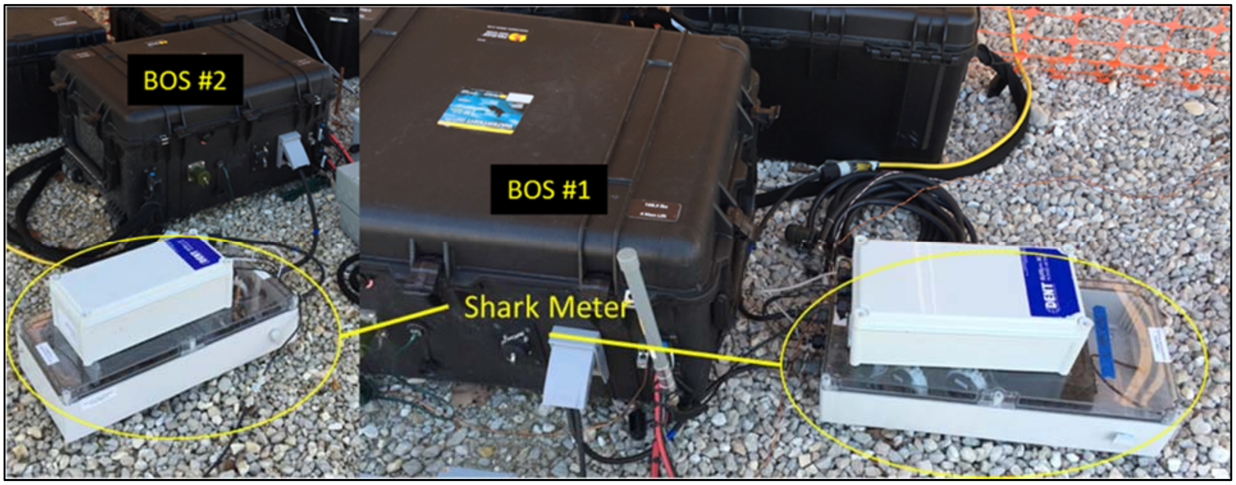


Figure 50: PSHADE Shark Meters

Additionally, in order to measure DC power, the PSHADE had a total of eight DC voltage and current transducers, with two DC voltage transducers and two DC current transducers per BOS box (**Figure 51**).

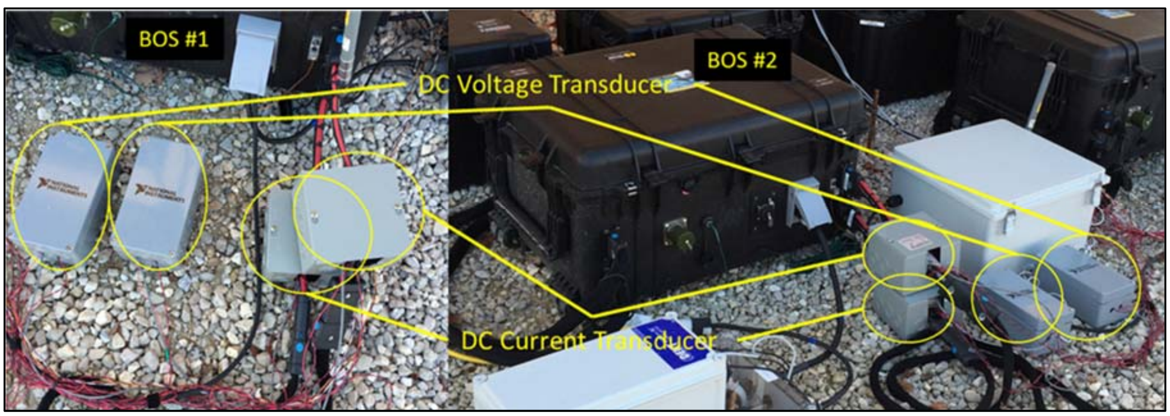


Figure 51: PSHADE DC Voltage and Current Transducers

The PSHADE was instrumented with pyranometers and temperature detectors (**Figure 52**) both under the shade and on top of it to measure the shade's effectiveness.

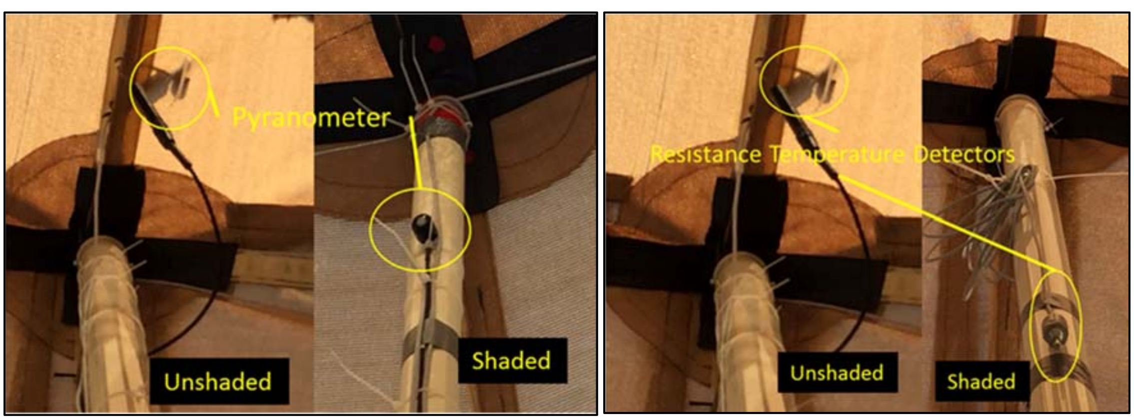


Figure 52: Pyranometer and RTDs in PSHADE

The PSHADE’s instruments were wired into an A2D box for data transmission and storage (**Figure 53**).

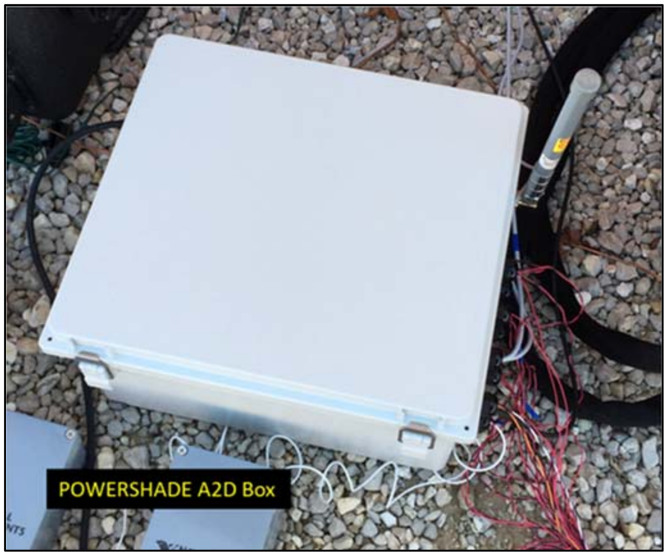


Figure 53: A2D Box for PSHADE

3.3.6 EIO-C Instrumentation

The EIO-C was instrumented to collect power and fuel data.

Table 7 is an extract of the DSM mapping data elements to instruments.

Table 7: EIO-C Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
Ambient Temperature (weather station)	°F	.1 °F	Electronic (TC)	Time Series	Weather Station
Power Factor for each generator		0.01			
Generator Voltage	VAC	.01Vac	electronic	time series	DMMS 200A
Generator Current	IAC	.01Aac	electronic	time series	DMMS 200A
Generator power	kW	1 Watt	electronic	time series	DMMS 200A
Generator power factor	dimensionless	0.001	electronic	time series	DMMS 200A
Generator fuel consumption line-in	gal/hours	.1 gal (.001)	electronic	time series	Floscan 8500 - DMMS
Generator fuel consumption line-out	gal/hours	.1 gal (.001)	electronic	time series	Floscan 8500 - DMMS
B-Hut Convenience Power consumed	kW	watt	electronic	time series or calculation	DMMS 60A
B-Hut ECU Power consumed	kW	watt	electronic	time series or calculation	DMMS 60A
B-Hut Internal Temperature	°F	.1 °F	Electronic (TC)	Time Series	RTD
B-Hut Peak Load	kW	watt	electronic	Single Measure	DMMS 60A
B-Hut Time Associated with Peak Load	HH:MM:SS	Second	electronic	Single Measure	DMMS 60A
B-Hut Temperature Associated with Peak Load	°F	.1 °F	Electronic (TC)	Single Measure	DMMS 60A
B-Hut Frequency		.01 Hz			DMMS 60A

There were four EIO-C 60K generators (**Figure 54**), each with an associated DMMS box (**Table 8**). A 30kW generator was also present but not instrumented.

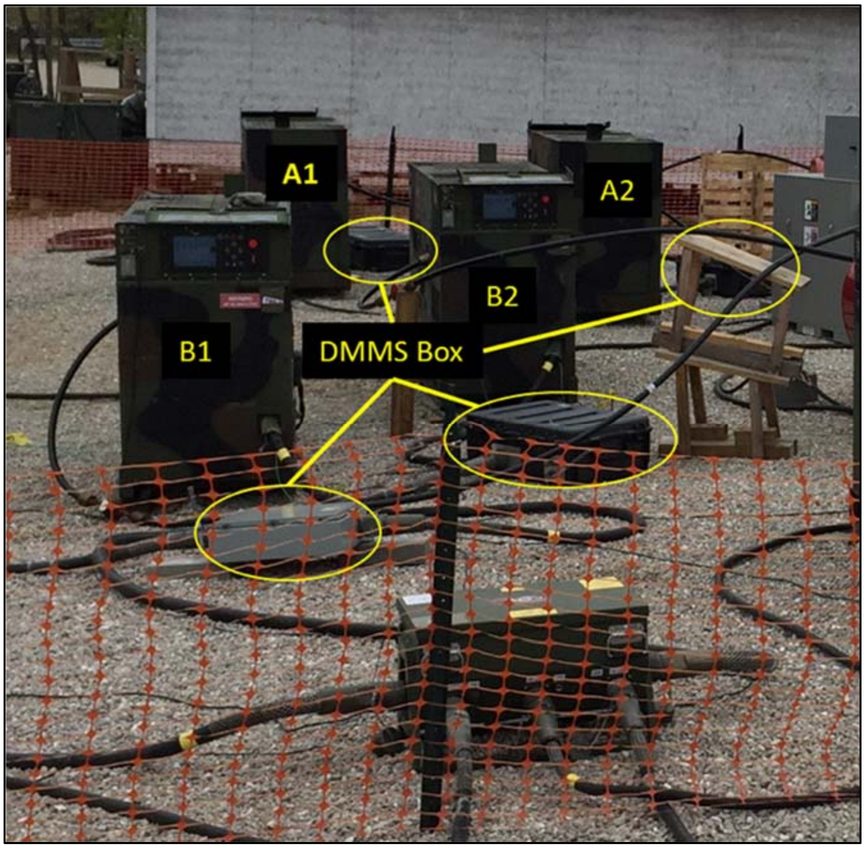


Figure 54: EIO-C 60kW Generators with DMMS Boxes

Table 8: DMMS Box Allocation to TQGs

Generator	Model	DMMS Box
A1 (60K-TQG-#4)	HX71023 – MEP-806B	AA15
A2 (60K-TQG-#3)	HX71645 – MEP-806B	AA13
B1 (60K-TQG-#1)	HX71170 – MEP-806B	AA19
B2 (60K-TQG-#2)	HX62048 – MEP-806B	New Box 22
30K	HX38722 – MEP-805B	N/A

The EIO-C generators provided power to the B-Hut and SIP-Hut billets as well as to the ECUs attached to the huts. **Figure 55** shows examples of an IECU, SIP-Hut, F100, and B-Hut.

Figure 55: IECU, SIP-Hut, F100, B-Hut

The huts on A-block had power monitored through DMMS boxes, the allocation of which is shown in **Table 9**.

Table 9: DMMS Box Allocation to Huts

Hut Number	Hut Type	ECU Type	DMMS Box
1A	B-Hut	IECU	AA04
1B	B-Hut	IECU	AA10
1C	B-Hut	IECU	AA03
1D	B-Hut	IECU	AA09
1E	B-Hut	IECU	AA07
1F	B-Hut	IECU	AA05
1G	B-Hut	F100	AA08
1H	B-Hut	IECU	AA02
S1	SIP-Hut	IECU	AA11
S2	SIP-Hut	IECU	New Box 33

The huts on B-block had DENT meters installed in the hut power boxes monitoring their billet power. For four of the huts, Shark meters were used to monitor ECU power, and two had DENT meters installed in the F100s. Power meter allocation is shown in **Table 10**.

Table 10: Power Meter Allocation to Huts

Hut Number	Hut Type	ECU Type	Billet Instrumentation	ECU Instrumentation
2A	B-Hut	F100	Dent ElitePro XC1311178	Shark Meter 61
2B	B-Hut	F100	Dent ElitePro XC1311174	Dent ElitePro XC1312030
2D (Demonstration Operations Center (DOC))	B-Hut	F100	Dent ElitePro XC1311151	Shark Meter 62
2E (Data Management Center (DMC))	B-Hut	F100	Dent ElitePro XC1312028	Shark Meter 63
2G	B-Hut	F100	Dent ElitePro XC1311175	Shark Meter 64
2H	B-Hut	F100	Dent ElitePro XC1312020	Dent ElitePro XC1312026

To monitor fuel usage, Floscan 8500 meters were installed on the generators, and to monitor fuel flow from the refuel tanks, AMCO meters were installed on the input fuel lines. These meters are shown in **Figure 56**.

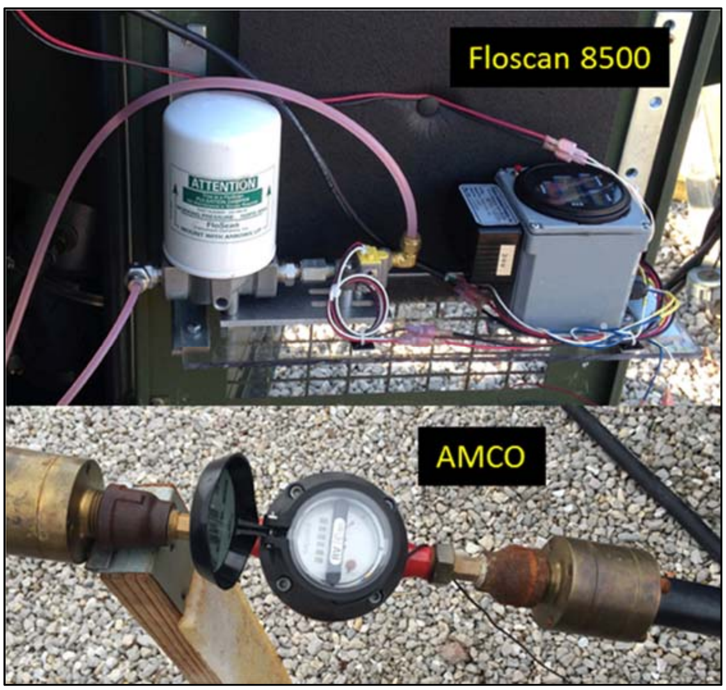


Figure 56: Floscan 8500 fuel meter on generators

3.3.7 DMMS Instrumentation

DMMS was used to monitor the camp and used as the core data collection framework. The location for all of the DMMS boxes can be seen in **Figure 57.**

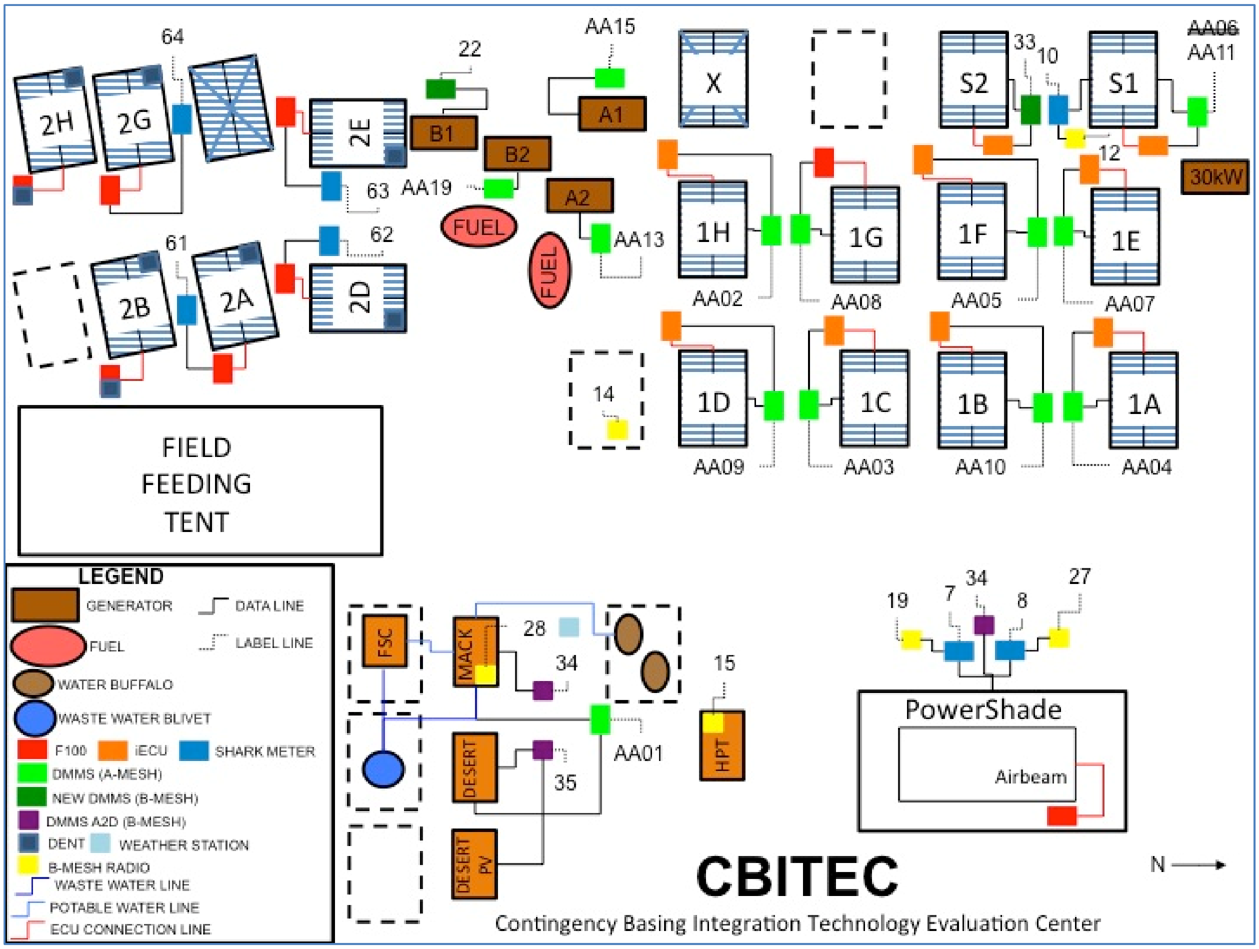


Figure 57: DMMS Instruments Location

3.3.8 HPT Instrumentation

Instrumentation internal to the HPT was used to collect power data.

Table 11 is an extract of the DSM mapping data elements to instruments.

Table 11: HPT Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
3 phase Combined Voltage	VAC	0.01	electronic	Time Series	DMMS
3 Phase Combined Current	AAC	0.01	electronic	Time Series	DMMS
Peak Load (power draw)	kW	0.01	electronic	calculated	DMMS
Peak Load (power draw)	VAC	0.01	electronic	calculated	DMMS
Peak Load (power draw)	AAC	0.01	electronic	calculated	DMMS
Peak Power Consumed	kWh	0.01	electronic	calculated	DMMS
Time to charge battery (Minutes) – time between TQG turn-on and turn-off	Time (HH:MM:SS)	s	internal HPT logs		Timer
Time between TQG turn-on and turn-off	Time (HH:MM:SS)	s	internal HPT logs		Timer
Load - power draw during elapsed time TQG turn-on to off	kW	0.01	electronic	calculated	DMMS
TQG run times (Minutes) – for each TQG turn-on and turn-off	Time (HH:MM:SS)	s	internal HPT logs		Timer
Total Fuel Consumption for the demonstration	Gallons	0.1	electronic	Single Measure	DMMS
Time to discharge battery (Minutes) – time between TQG turn-off and turn-on	Time (HH:MM:SS)	s	internal HPT logs		Timer
Load – power draw during elapsed time TQG turn-off to turn-on	kW	0.01	electronic	calculated	DMMS
Time between TQG turn-off and turn-on	Time (HH:MM:SS)	s	internal HPT logs		Timer

Figure 58 shows the HPT control panel. The information on the control is transmitted through the B-mesh radio network to the DDMS server for data collection. No additional instrumentation was added to the HPT.

Figure 58: HPT Control Panel

3.3.9 SIP-Hut Instrumentation

The SIP-Huts were instrumented to collect power, temperature, and humidity data. **Table 12** is an extract of the DSM mapping data elements to instruments.

Table 12: SIP-Huts Data Source Matrix

Data Element	Unit	Scale	Collection Method	Data Type	Sensor Type (if used)
Shelter Orientation (longest Wall orientation)	Direction	1 °	Manual	Single Measure	Manual DC Form
Ambient environmental conditions during testing: Solar, Rain, humidity, temperature and wind speed.	Various	Various	Weather Station	Time Series	Weather Station
Internal temperature - center of shelter	°F	.1 °F	Electronic	Time Series	ProSense RTD TTD25N-20-0300F-H
temperature at the Return duct (inside the structure)	°F	.1 °F	Electronic	Time Series	ProSense RTD TTD25N-20-0300F-H
Humidity	%	0.01	Electronic (HS)	Time Series	HM1500LF Humidity Meter
ECU set point	N/A	N/A	Manual	Photograph	Manual DC Form
Energy consumed by ECU	kWh	0.001	Electronic	Time Series	DMMS 60A
Lights? Convenience?	kWh	0.001	Electronic	Time Series	DMMS 60A
Total Energy Consumption	kWh	0.001	calculated rollup	Calculation	DMMS 60A

Power for SIP-Hut 1 was monitored by a standard DMMS box, while power for SIP-Hut 2 was monitored by a new-type DMMS box (**Figure 59**). The other instrumentation for the SIP-Huts was wired into the new-type DMMS box.

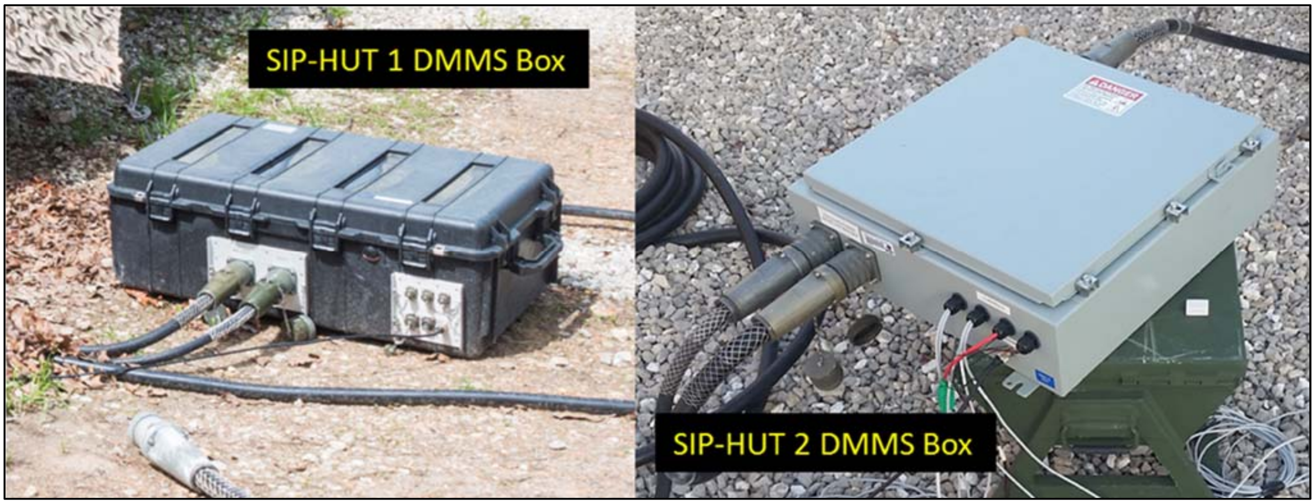


Figure 59: SIP-Hut DMMS Boxes

A Shark meter monitored power for the air exchanger in the SIP-Huts (**Figure 60**).

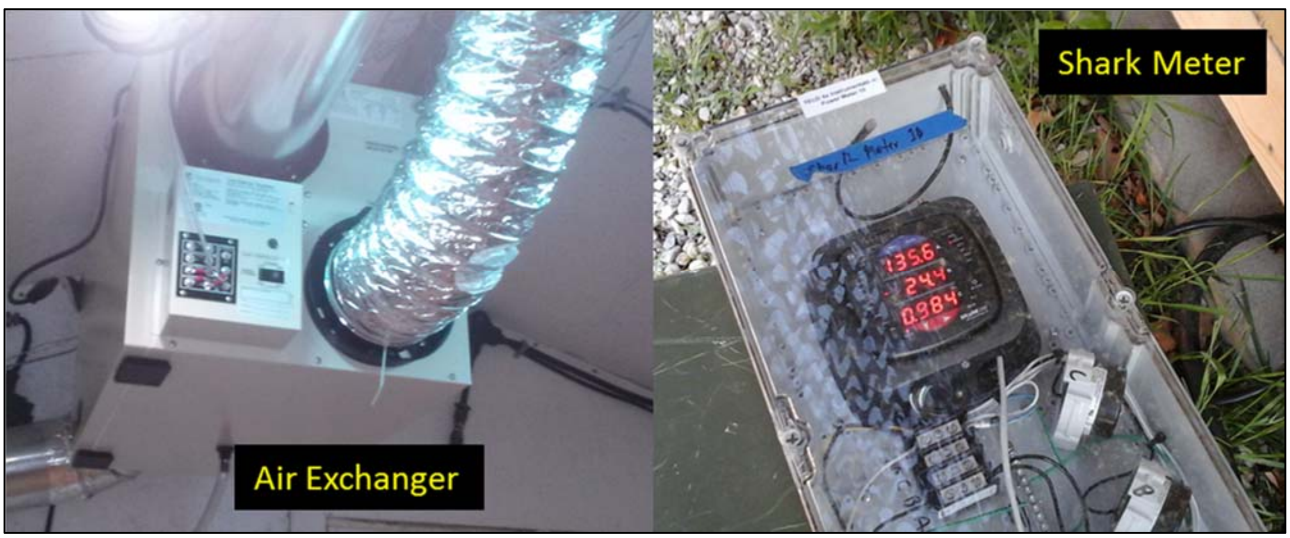


Figure 60: Shark Meter for Air Exchanger

HM1500F humidity sensors were installed in each SIP-Hut hanging from the central rafter near the central support beam (**Figure 61**).

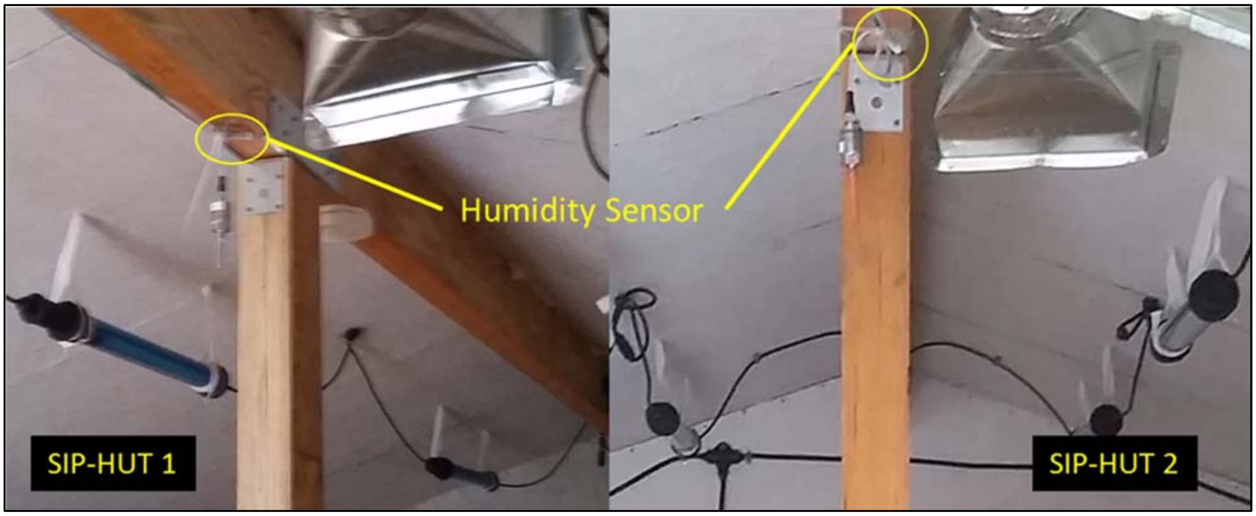


Figure 61: SIP-Hut Humidity Sensors

ProSense RTDs were installed near the humidity sensors on the middle rafter, as well as in the ECU air return ducts (**Error! Reference source not found.**). Handheld temperature and humidity meters, model RHT 20, were placed in the SIP-Huts to collect data overnight while the SIP-Huts were not powered. They were placed on cots next to the central beam of the hut **(Error! Reference source not found.**).

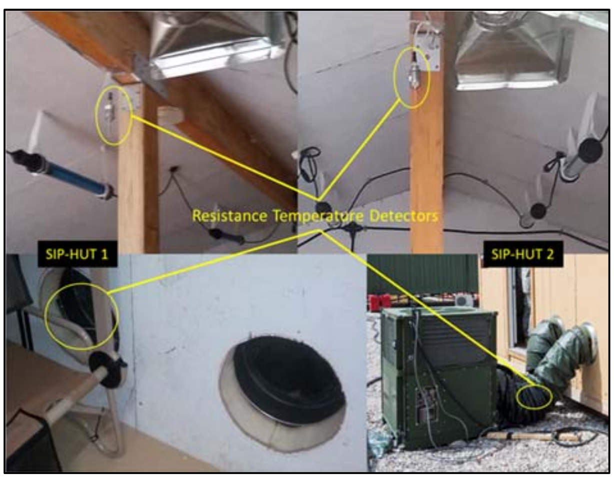


Figure 62: SIP-Hut RTDs

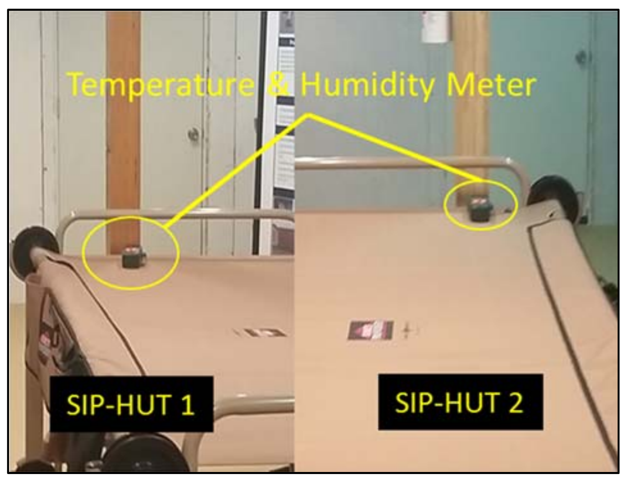


Figure 63: Handheld Sensors in SIP-Hut

4. METHODS

This chapter describes the data collection activities and data handling processes from the start of the integrated demo through authentication of the data. Soldier training is also addressed.

Baseline data elements were collected for B-Huts, F100s, and IECUs as part of the EIO-C data collection. Baseline data elements were collected on IECUs as part of the SIP-Hut data collection. Baseline data was collected on the FSC as part of the MACK data collection. See the respective sections below for details. There was no data collected on the TEMPER display tent; none was required.

4.1 MACK Data Collection

MACK operation and data collection was a highlight of this demonstration. To collect data on the MACK, the SLB-STO-D and MSCoE planned and executed a field feeding event for 800 Soldiers. MACK data was collected in preparation for this event during Soldier cook training and rehearsals. Data files were collected during operations from 14-17 April and 19-23 April 2015.

The MACK was set up on a concrete slab. The FSC was set up on an adjacent slab to the right of the MACK, facing the troop entrance. The MACK and the FSC drew water from a water buffalo situated to the left of the MACK (just for reference, the DESERT was set up directly behind the MACK). The MACK was powered by the HPT.

Power and water were metered as described in the instrumentation section above. JP-8 fuel data were manually collected before and after each operation by filling each appliance fuel tank then weighing the fuel tank before and after cooking (see **Figure 64**).

Figure 64: MACK Fuel Data Collection

A summary of the daily activities for MACK data collection follows:

14 April: Operated appliances to verify data collection.

15 April: Operated appliances and conducted noise level data collection.

All doors and windows were closed and zipped up. The MACK was connected to shore power. For each test, a decibel reading was recorded at each of the six locations identified in **Figure 65**.

a. Baseline – nothing powered.
b. Modular Appliances – no vent hood, all MACK appliances "on" (serving line, griddles, skillets, and ovens).
c. Typical Idle State – lights, vents, fans, and refrigerator.
d. Typical Idle State and Modular Appliances – lights, vents, fans, refrigerator, and MACK appliances.
e. Everything with Shore Power – lights, vents, fans, refrigerator, MACK appliances, warming oven, and running water in the sink (with onboard pump).
f. Everything with Onboard Generator Power – lights, vents, fans, refrigerator, MACK appliances, warming oven, and running water in the sink (with onboard pump).

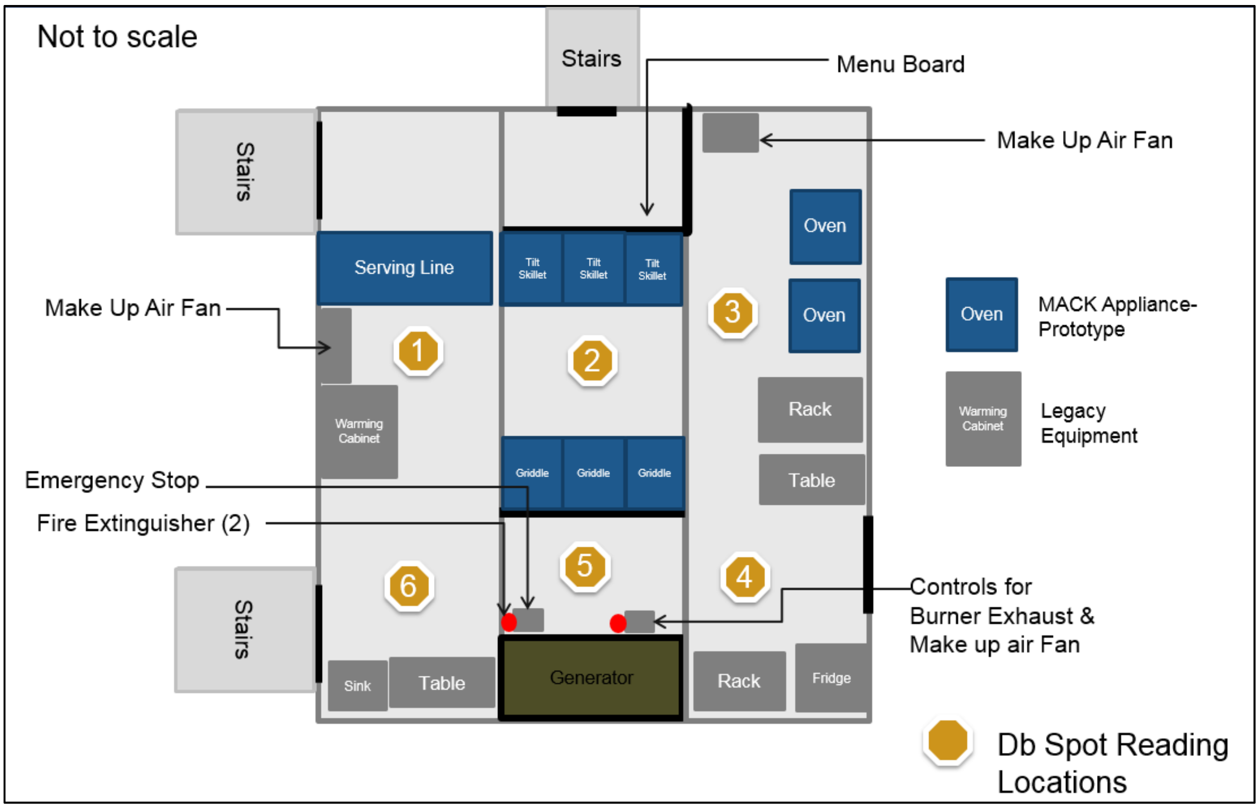


Figure 65: MACK Noise Level Data Collection

16 April: Conducted a 4-hour burner baseline data collection event.

17 April: Exercised the MACK to train Soldier cooks, MOS 92G, and prepared 200 UGR-A rations. Images from the training are shown in **Figure 66** and **Figure 67**.

Figure 66: 92G Training (1 of 2)

Figure 67: 92G Training (2 of 2)

19 April: No cooking on this day. Harvested data for the internal refrigerator (found that there had been a power failure sometime the previous day, so the MACK was not powered on this day).
20 April: Conducted a 15-min burn on the appliances to make sure data collection was ready for the field-feeding event the next day.

21 April: Prepared 800 UGR-A meals for the field feeding exercise. Images from the field feeding op are shown in **Figure 68** and **Figure 69**.

Figure 68: Field Feeding Op

Figure 69: VIPs at Field Feeding Op

22 April: Prepared 100 UGR-A meals for the Stakeholder Day.

23 April: Completed burner baseline data collection.

4.2 DESERT Data Collection

The DESERT was set up on the concrete pad behind the MACK and its solar panel was set up on the concrete pad behind it (**Figure 5** in Section 2.2). The DESERT drew power from its solar panel and from the HPT. Ordinarily, the solar panel could be erected over the DESERT to provide additional shade and energy savings, but the sloping terrain did not allow this option.

The DESERT was used operationally to store frozen and fresh rations for the MACK operations. In addition, there had been the goal to run some technical scripts to evaluate two variables – (a) temperatures in separate compartments, frozen or cold, and (b) a number of door openings versus entirely sealed doors. While the scripts were not able to be run strictly according to design, there was some variability in the operation when frozen foods were removed or transferred to the cold section. There was also the unplanned addition of wet ice, which introduced another variable – excess humidity – into the data collection. Data files were authenticated for operations from 13-23 April.

A summary of the daily activities for DESERT data collection follows:

13 April: Setpoints at -5 °F in freezer section (**Figure 70**) and 35 °F in refrigerator section (**Figure 71**). Loaded rations. Switched fresh food section to 38 °F to protect vegetables from freezing. Switched power from onboard genset to 60kW TQG to supplement solar while the HPT was repaired.

Figure 70: Freezer Section

Figure 71: Refrigerator Section

14 April: No door openings. Maintained temperatures.

15 April: Switched back to HPT power. Removed 200 meals from freezer section and put in refrigerator section.

16 April: Opened freezer to remove rations for the following day’s training. Marinated the rations and returned them to the refrigerator compartment. Total of four door openings. **Figure 72** shows the moving of the rations.

Figure 72: Moving Rations

17 April: Multiple door openings and closings. Placed some ice in freezer compartment. Did not reach the freezer set point of -5 °F after opening freezer in the morning and removing 800 steaks. On advice of SunDanzer conducted two manual defrost cycles. Very little water dripped out.

18 April: Freezer compartment did not perform optimally, not quite reaching its set point. Opened the freezer compartment and found the fins totally caked with ice. Between 1100 and 1300 hours performed a total of five manual defrost cycles to clear some of the ice. About a third of the fins cleared.

19 April: Conducted defrost cycles and other troubleshooting most of the day to clear ice from fins in freezer.

20 April: Did very well overnight holding set point after extensive defrosting previous day. Reprogrammed with improvements to DEFROST functionality. Removed remaining food from freezer. Freezer set point raised to 5 °F for empty condition.

21 April: Multiple door openings to retrieve food and ice. Multiple door openings to reinstall food after the meal was complete.

22 April: Unloaded rations and loaded leftovers.

23 April: Continued to operate at 5 °F and 38 °F.

4.3 WATERMON Data Collection

Data was not collected on the operation of the WATERMON per se, since this technology is itself a data collection instrument. Lisa Neuendorff, TARDEC, developed a detailed operating procedure for the YSI Sonde (Error! Reference source not found. and Error! Reference source not found.) and conducted all WATERMON operations at the water treatment plant. In addition, Frontier Technology collected water samples according to a protocol developed by the Public Health Command. These samples were shipped on a predetermined schedule to a lab for analysis. The WATERMON data and the water sample data could be used to assess the source wastewater and the treated effluent to evaluate the efficiency of the WWT-Bio.

Figure 73: YSI Sonde

Figure 74: Sonde in Effluent Capture

4.4 WWT-Bio Data Collection

Frontier Technology delivered and installed the WWT-Bio (**Figure 75**) at the Fort Leonard Wood water treatment plant during the first week of March. EDVT traveled to Fort Leonard Wood the second week and instrumented the system for data collection. Frontier installed a header tank (**Figure 76**) to stabilize the input rate. Both EDVT and the contractor collected data on the WWT-Bio operation. EDVT collected data as described in Section 3.3.4. Frontier used their onboard power and water flow meters to collect data as well. EDVT data collection started on 12 March and ran continuously through 20 April.

The system ran autonomously unattended around the clock. Representatives from Frontier checked on the system a couple of times a week and collected water samples as noted above. They reported system status directly to TARDEC. A few data milestones are noted below.

12 March: UV light apparently broken in shipment, causing a leak. Installed a valve to shut off the backflow. Frontier reported the flow at about 4 gal/min. Main blower and pump operated in manual mode using a timer.

13 March: Turned off pump and main blower to install monitoring equipment.

15 March: Timer may have malfunctioned and pump and main blower remained ON continuously.

Figure 75: WWT-Bio Operational

Figure 76: Header Tank for WWT-Bio

17 March: Installed the dissolved oxygen (DO) meter. The main blower now controlled by the DO level. The pump still operated at 30 min ON/30 min OFF pattern.

26 March: Observed sharp decrease in influent strength to one-third of normal, corresponding to a drop-off in power demand.

1 April: Frontier reported the UV light was fixed, the system was working well, and the microorganisms were maturing.

2 April: Later found that the low water influent float was tipped over and the pump was OFF for 4 days.

6 April: Discovered and repaired the issue with the float and the system was again operational.

9 April: Frontier reported that the system was operating at a 2000 gpd flow rate.

13 April: Increased the flow rate to 6000 gpd.

14 April: EDVT collected sludge data by weighing on a scale (**Figure 77**). This procedure and these data were deemed unsuitable and the data were not delivered.

Figure 77: Weighing Sludge

16 April: Frontier reduced the flow rate back to 3000 gpd (normal load). The sludge wasting flow was also reduced accordingly.

4.5 PSHADE Data Collection

The technology provider and contracted vendor erected the PSHADE (**Figure 78**) at CBITEC during the second week of March, well in advance of the demonstration. The PSHADE was operational and charging the batteries in the Multi-Mode Grid Tie Balance of Systems (MMGT-BOS). The early arrival was to allow the provider to collect data in support of the Demonstration Prep Phase. Unfortunately, this data collection did not occur and these data are not available. CBITEC erected a TEMPER tent (**Figure 79**) under the shade.

Figure 78: PSHADE Setup

Figure 79: TEMPER Setup

The PSHADE was integrated with the HPT system through a grid-tie. The PSHADE was set up to power the lights and electronics in the display tent. There was concern about the PSHADE sending excess power back to the HPT if not consumed by the lights and electronics. The ECU was added to the PSHADE load and kept in vent mode to serve as a type of load bank.

The EDVT completed instrumentation of the system and integration with DMMS and data files were collected for the period from 13-24 April. The operation of the PSHADE was rather passive and only dependent on sunshine outside the tent and operation of lights, electronics, and ECU inside the tent. There was no script to manipulate the load.

4.6 EIO-C Data Collection

Communications-Electronics Research, Development and Engineering Center (CERDEC) installed the EIO-C (**Figure 80**) to power the A-block of B-Huts and the B-block of B-Huts. This was not a single grid of five generators as originally planned, but two separate grids each with two 60kW TQGs. The 30kW TQG was eventually used to power the SIP-Huts without EIO-C functionality. The team set up their application in the DOC (**Figure 81**).

Figure 80: EIO-C Grid Set Up

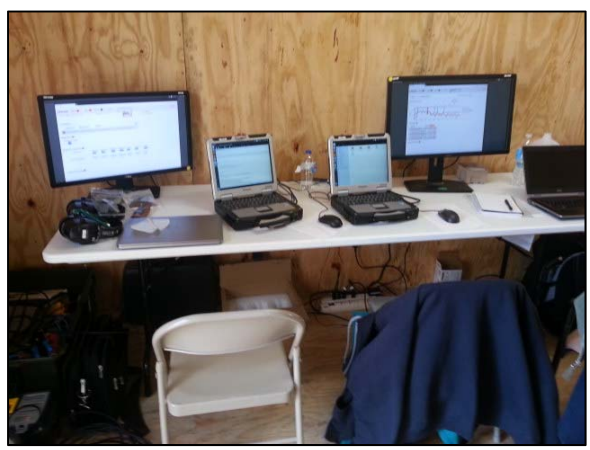


Figure 81: EIO-C Application in DOC

The CERDEC subject matter expert (SME) to the EDVT used the AutoDISE tool to map the EIO-C grids. **Figure 82** through **Figure 86** chart the EIO-C grids.

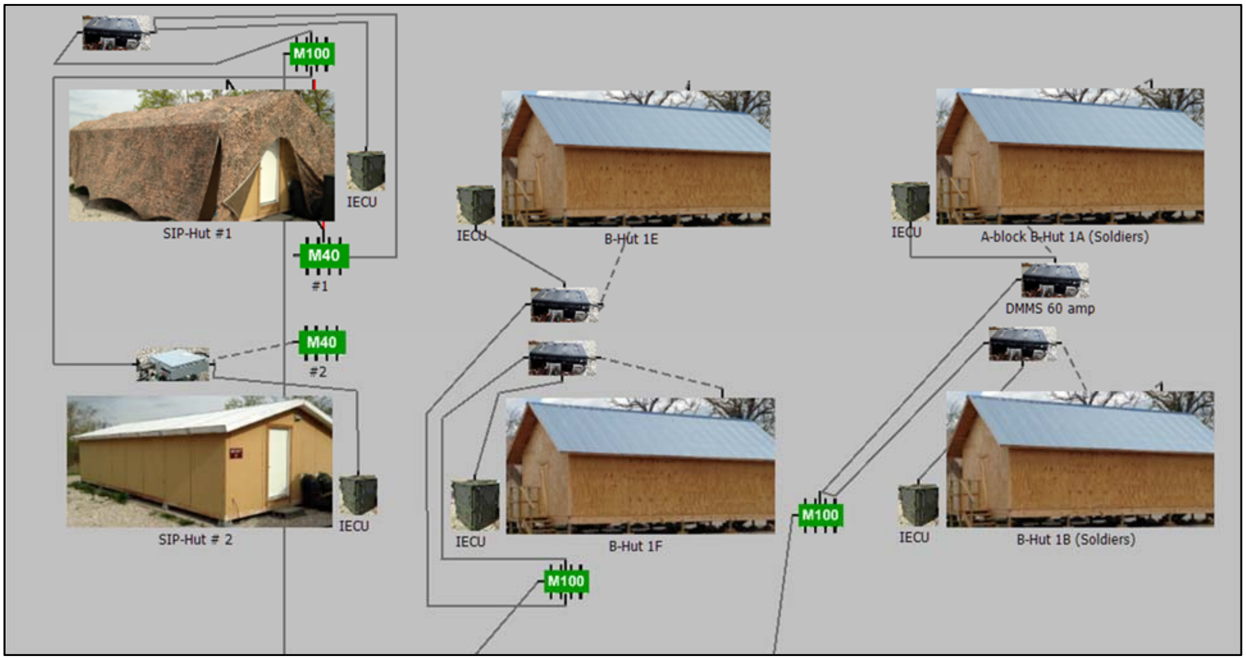


Figure 82: EIO-C AutoDISE Map (1 of 5)

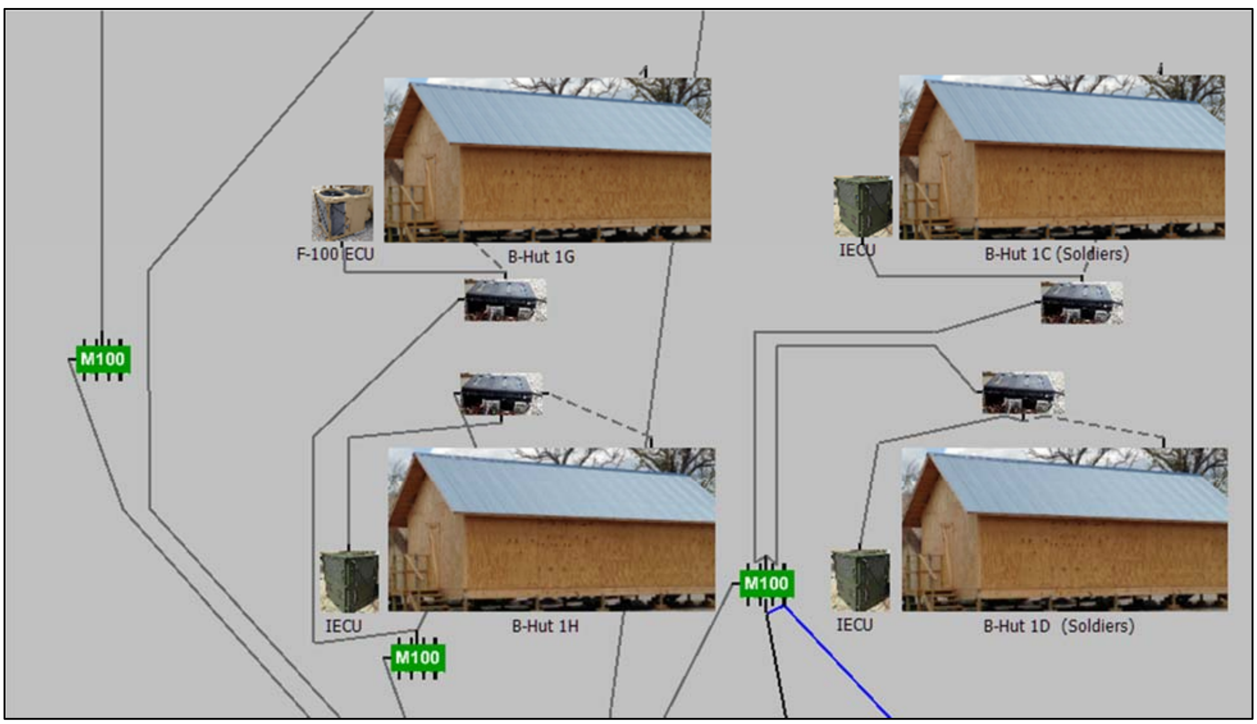


Figure 83: EIO-C AutoDISE Map (2 of 5)

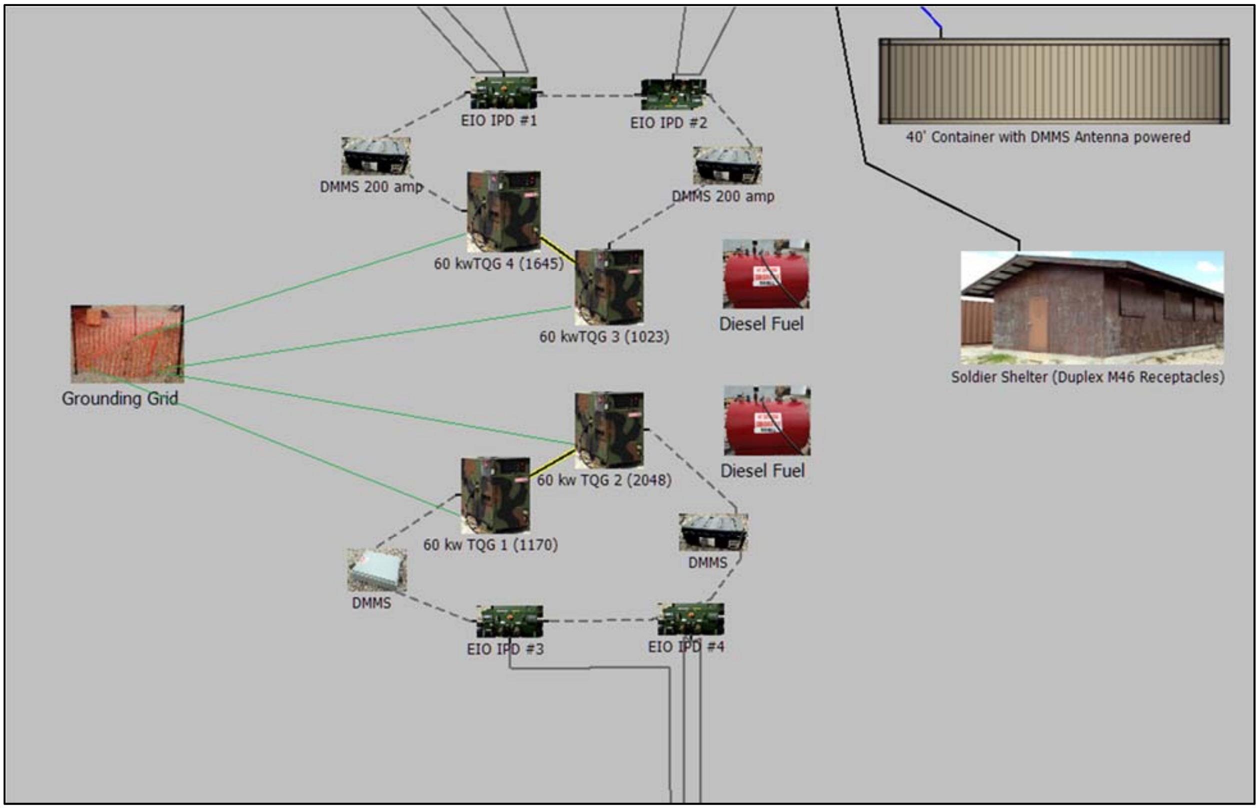


Figure 84: EIO-C AutoDISE Map (3 of 5)

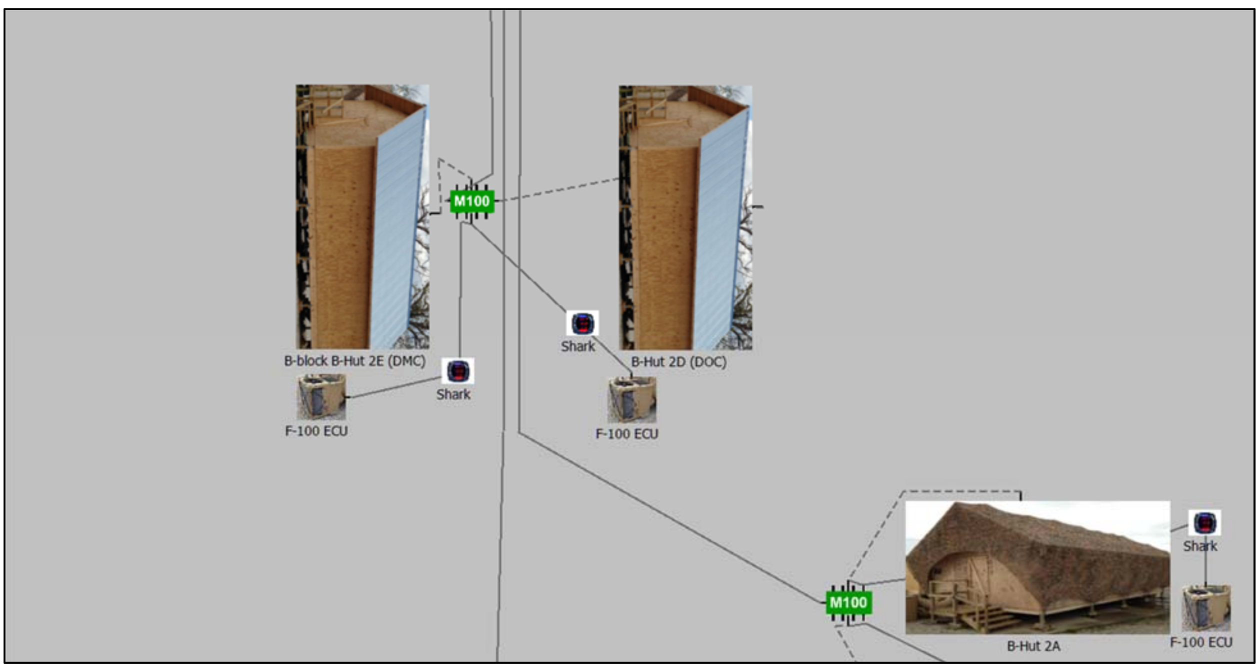


Figure 85: EIO-C AutoDISE Map (4 of 5)

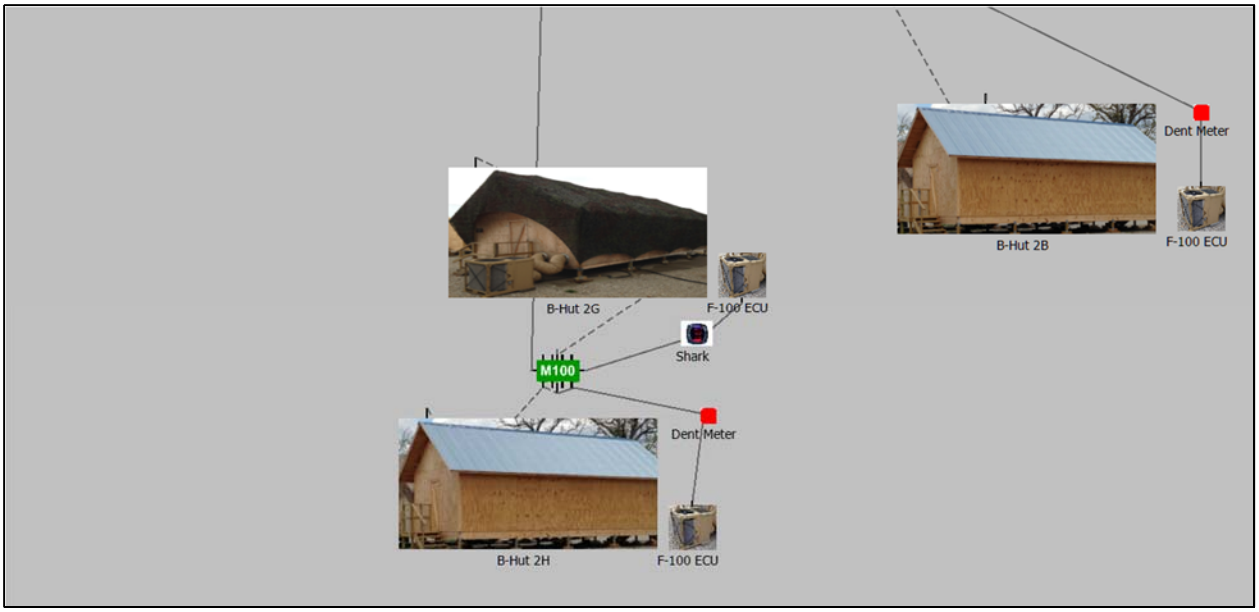


Figure 86: EIO-C AutoDISE Map (5 of 5)

CERDEC conducted much testing and troubleshooting to get the grids operational and stable. The team was able to get the A-block of B-Huts running reliably prior to occupation by Soldiers of the Military Police Basic Officer Leaders Course (MP BOLC) class. The B-block of B-Huts required more testing. EDVT collected data files from 13-23 April.

A summary of the daily activities for EIO-C data collection follows:

13-15 April: SEIT ran operational scripts to vary the load on the A-block grid when the huts were unoccupied. Details were collected manually on paper forms and transcribed to Excel. The scripts are included with the Deliverable Dataset workbooks. **Table 13** shows a sample script.

Table 13: EIO-C Manual Data Collection Sample

ECU SETTING				
Time	Measured Value	Location (which Hut)	Initials	Comments
10:00	heat-max	1A-1H	WL	
10:30	vent	1A-1B	WL	
11:00	vent	1C-1D	WL	
11:30	vent	1E-1F	WL	
12:00	vent	1G-1H	WL	
12:30	cool-max	1A-1G (?)	WL	
13:00	vent	1A-1B	WL	
13:30	vent	1C-1D	WL	1D was not as cold as C
14:00	vent	1E-1F	WL	
14:30	vent	1G-1H	WL	

16 April: EIO-C powered the A-block for the unit in residence. This began a period of 24-hour operation to support the Soldiers.

17-22 April: EIO-C powered the A-block 24/7 for the unit and powered the B-block including the DOC and DMC.

23 April: Ran data collection scripts on the A-block and the B-block.

24 April: Conducted sound test. See **ANNEX B** for Methods and Results.

4.7 DMMS Data Collection

The SLB-STO-D did not collect data on the DMMS. Like the WATERMON, the DMMS is itself a data collection capability. The only data collected on DMMS came in the form of Soldier feedback following an orientation to the system.

4.8 HPT Data Collection

The HPT (**Figure 87**) powered the MACK, provided supplemental power to the DESERT (**Figure 88**), and provided a grid-tie for the PSHADE. There was no script or deliberate manipulation of the loads other than operational. Data files were collected for the period from 14-23 April.

Figure 87: HPT with PDISE

Figure 88: Power Distribution from HPT to MACK and DESERT

A summary of the daily activities for HPT data collection follows:

14 April: Alternator on HPT was replaced and the system put back into operation in the evening. Charged internal batteries overnight.

15 April: After charging batteries overnight, applied power to the DESERT and the MACK.

16-17 April: Added the display tent ECU to the load.

18 April: HPT had shutdown sometime during the night. Restarted the HPT and power was restored to the DESERT and the MACK.
19 April: Powered display tent, DESERT and MACK.

20-22 April: Added the electrical load for the AV equipment in the dining shelter erected for the field feeding operation and the visitor day.

23 April: Powered display tent, DESERT, and MACK.

4.9 SIP-Hut Data Collection

The SIP-Huts were powered by either a 30kW TQG supplied by CERDEC or by the EIO-C grid. Originally, the 30kW TQG was intended to be part of the EIO-C microgrid, but was not needed. **Table 14** shows the power source for the SIP-Huts by date.

Table 14: SIP-Hut Power Source by Date

13-Apr	30kW
14-Apr	30kW, thermal degradation
15-Apr	30kW
16-Apr	30kW
17-Apr	30kW am, EIO PM
18-Apr	EIO
19-Apr	EIO
20-Apr	EIO
21-Apr	EIO
22-Apr	EIO pm, thermal degradation
23-Apr	30kW pm, thermal degradation
24-Apr	30kW pm, thermal degradation

Where "thermal degradation" is indicated, the huts were warmed up during the day per the script, then the power was shut off and the huts were allowed to cool during the night

The SIP-Huts were instrumented and ECUs were installed (**Figure 89** and **Figure 90**). The SEIT developed scripts to vary the amount of fresh air exchanged – 0, 50, or 100% of the vent holes in the ECU ducts exposed (**Figure 91)** – and with the air exchanger (**Figure 92).**

Figure 89: SIP-Hut with IECU

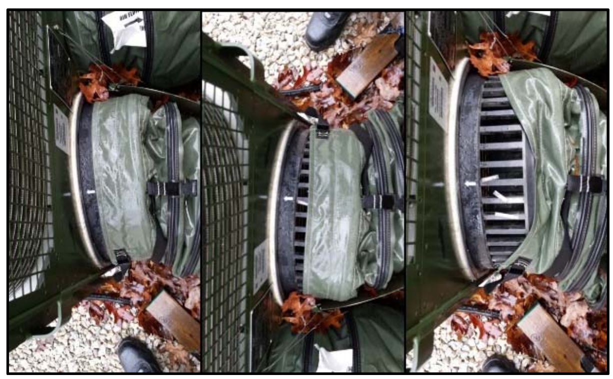


Figure 90: IECU Vent Positions

Figure 91: Return and Supply Openings in SIP-Hut

Figure 92: Air Exchanger in SIP-Hut

SEIT recorded actual settings on manual data collection sheets. These were transcribed to Excel (**Table 15**), and integrated into the Deliverable Dataset workbooks. Data files were collected for the period from 13-25 April.

Table 15: SIP-Hut Manual Data Collection Sample

ECU SETTING					ECU SETTING				
Time	Measured Value	Location (which Hut)	Initials	Comments	Time	Measured Value	Location (which Hut)	Initials	Comments
8:25		SIP-1	JCL	generator on	8:25		SIP-2	JCL	generator on
8:30		SIP-1	JCL	ECU set to med heat; ducts 50%	8:30		SIP-2	JCL	ECU set to med heat; ducts 50%
15:42		SIP-1	JCL	switch to vent	15:42		SIP-s	JCL	switch to vent
17:45		SIP-1	JCL	generator off	17:45		SIP-2	JCL	generator off
17:15				Generator off	17:15				Generator off
19:55				IR pictures	19:55				IR pictures

A summary of the daily activities for SIP-Hut data collection follows:

13 April: Applied power (30kW TQG) to the huts according to script. Identified a problem with an IECU not cooling.

14 April: Replaced the inoperative IECU with the IECU from B-hut 1G. Ran data collection on the SIP-Huts. Left the IECU in HEAT mode until about 1700 hours, then turned off to assess thermal degradation. AMSAA returned to the range at night to take thermal images of the huts and measure the internal temperature.

15 April: Executed script.

16 April: Executed script. Ran IECUs overnight.

17-18 April: Modified script to switch the IECU from COOL to HEAT during the nights and back to COOL during the daytime. Switched power source from 30kW TQG to the EIO-C grid on the evening of 17 April.

19-20 April: Kept IECUs in HEAT mode all day.

21 April: Executed air conditioning script and kept in COOL overnight.

22 April: Executed heating script. Conducted thermal degradation in the evening.

23 April: Switched back to the 30kW TQG for power source. Executed thermal degradation script.

24 April: Conducted sound test. See **ANNEX B** for Methods and Results.

4.10 Soldier Training

Soldiers participated in this demonstration in two key areas. First, twelve NCO students and one instructor from the Prime Power School (PPS) participated in training and briefings on power-related technologies. Second, eleven Soldiers and NCOs from the 5th Engineer Battalion and the 92d Military Police Battalion trained on the operation of the MACK and prepared meals in support of the field feeding operation and the Leadership Day. Each group participated in a focus group conducted by the Consumer Research Team from NSRDEC.

4.10.1 Prime Power School Training

From PPS, 12 students and 1 instructor visited CBITEC on Monday, 13 April. The SLB-STO-D briefed the Soldiers on the EIO-C, DMMS, HPT and POWERSHADE during a round-robin session in the morning. Details of this visit are recorded in **ANNEX C**. The Soldiers returned on Wednesday, 15 April, and participated in a focus group. The report from the focus group is found in **ANNEX D**. The PPS also sent instructors and students to visit the camp on 15 April. All training during this visit was conducted by the PPS instructors, not the SLB-STO-D.

4.10.2 Soldier Food Specialist Training

A training plan was developed to train the cooks. The training featured the following topics:

- Background on Demo
- Activities Onsite – Hands-on training; Field Feeding Operation
- Overview and Background on the equipment, including:
    - History of Mobile Kitchens
    - Containerized Kitchen-Improved (CK-I)
    - Safety Release: Risks and Hazards Overview
    - MACK
        - Hawkmoor - Prototype Burner
        - Griddle, Skillet, Convection Oven
        - Serving Line

The Soldiers received on-the-job training on 17 April and 20-22 April in the execution of the following tasks:

- Receive and Inspect Food (UGR-A Modules)
- DEFROST
- Prep for 200 meal field feeding
- Execute the 200 meal field feeding
- Prep for 800 meal field feeding
- Execute the 800 meal field feeding
- Execute the ration sampling 100 meal field feeding

The Soldiers participated in a focus group on 22 April. The report from the focus group is found at **ANNEX D**.

4.11 Supporting Data Collection

4.11.1 Environmental Data Collection

General venue environmental data were collected daily at the weather station nodes installed at the CBITEC (see Section 3.3).

4.11.2 Demonstration Incident Reports

The Demonstration Incident Report (DIR) was used to collect data on system and component failures, anomalies, repairs, etc. The DIR was also used to document "administrative" data, such as start times of record runs, site meetings, key stakeholder visits, etc. For this demonstration, paper copies of the DIR data collection form were used. Paper copies were submitted to the Demonstration Director as they were completed. The director reviewed the DIRs daily, entered them into an Excel spreadsheet, and submitted them to the data librarian (DL) to be cataloged. DIRs were presented to the Data Authentication Group (DAG) for authentication and delivered with the Deliverable Dataset.

4.11.3 Data Harvesting Methods

The EDVT in general works with two types of data: (a) data that are electronically collected by sensors/instrumentation, and (b) data that are collected manually by hand. Manually collected data for this project followed the same general format that the EDVT has used in the past. Forms were designed from the data identified in the DSM and personnel from the EDVT and other augmentees manually collected data and filled in the forms daily. These forms were collected and logged daily in the DMC. Electronic data was harvested daily from a number of sources and delivered to the DL, who archived it upon receipt. The DL is responsible for maintaining all data, preparing it for authentication and reporting to the DAG chair. In principal this is no different from the approach that the EDVT has taken with previous events. What was different for this event was that the EDVT was working with CBITEC's DMMS for the very first time. DMMS is discussed in greater detail below in Section 4.11.3.1.

Throughout the harvesting and reduction process, data was stored on a network attached storage (NAS) device. This NAS provided the members of the EDVT with easily accessible secure storage for working on data during the on-site period of the demonstration. Harvesting automatically collected data is easier and will be described first.

4.11.3.1 DMMS

Unlike the BCIL where they continuously store each of their measurement data in a My Structured Query Language (MySQL) database, CBITEC uses a different database and more importantly a completely different format. CBITEC's database uses a change of value (CoV) database which only stores data when the current measure changes from the previous value by a preset threshold. If the EDVT queried this database to harvest the data in the same manner as with the BCIL, the resulting files would contain what appeared to be 'gaps' in the data. During the periods of time when the measured value did not change, no update was applied to the

database which means there would be periods of time where there were not contiguous timestamps. There might be a value at one period of time and then none until hours later (appearing to be a gap in the data when instead the value did not change and no update was needed). Instead of taking this approach, the EDVT worked with CBITEC staff to have them export EDVT's data, and in the process of exporting the data, query the database and fill in the exported data with values for every sample period, even if the value did not change. This approach generated significantly more rows in the output data but ensured contiguous timestamps. This process produced export files that could easily be used by the EDVT to generate the deliverable data sets. Data from the DMMS database was harvested daily by EDVT staff using the export function built by CBITEC. This export function generated multiple export files, one file per technology, and is shown as Process 1 in **Figure 93**.

4.11.3.2 Non-DMMS Sensors

Some of the technologies demonstrated were not able to be instrumented by DMMS. WWT-Bio, for example, was geographically separated from TA-246 and therefore outside of the range of its wireless network. Other technologies like the B-block of B-Huts were not included in DMMS because of limited nodes and were instead instrumented with standalone Dent meters. These sensors either logged to a local server like the WWT-Bio, or wrote individual log files like the B-block Dent meters. These sensors are shown in Processes 2 and 3 in **Figure 93**.

4.11.3.3 EDVT Manually Collected Data by Tablet

It has been the intent of the EDVT to move all manual data collection from paper forms to data entry on electronic tablets since their first field data handling event. This demonstration marked the first attempt at electronic manual data collection. Harvesting this data is shown as Process 4 in **Figure 93**.

4.11.3.4 EDVT Manually Collected Data by Paper Forms

The EDVT was unable to use tablets for all of the manually collected data, and some data, like the DIRs, do not lend themselves to structured electronic collection since end users are not likely to take the time to provide sufficient information using that medium. Consequently, paper forms were used and then this data was manually transcribed to electronic media. This process is shown as Process 5 in **Figure 93**.

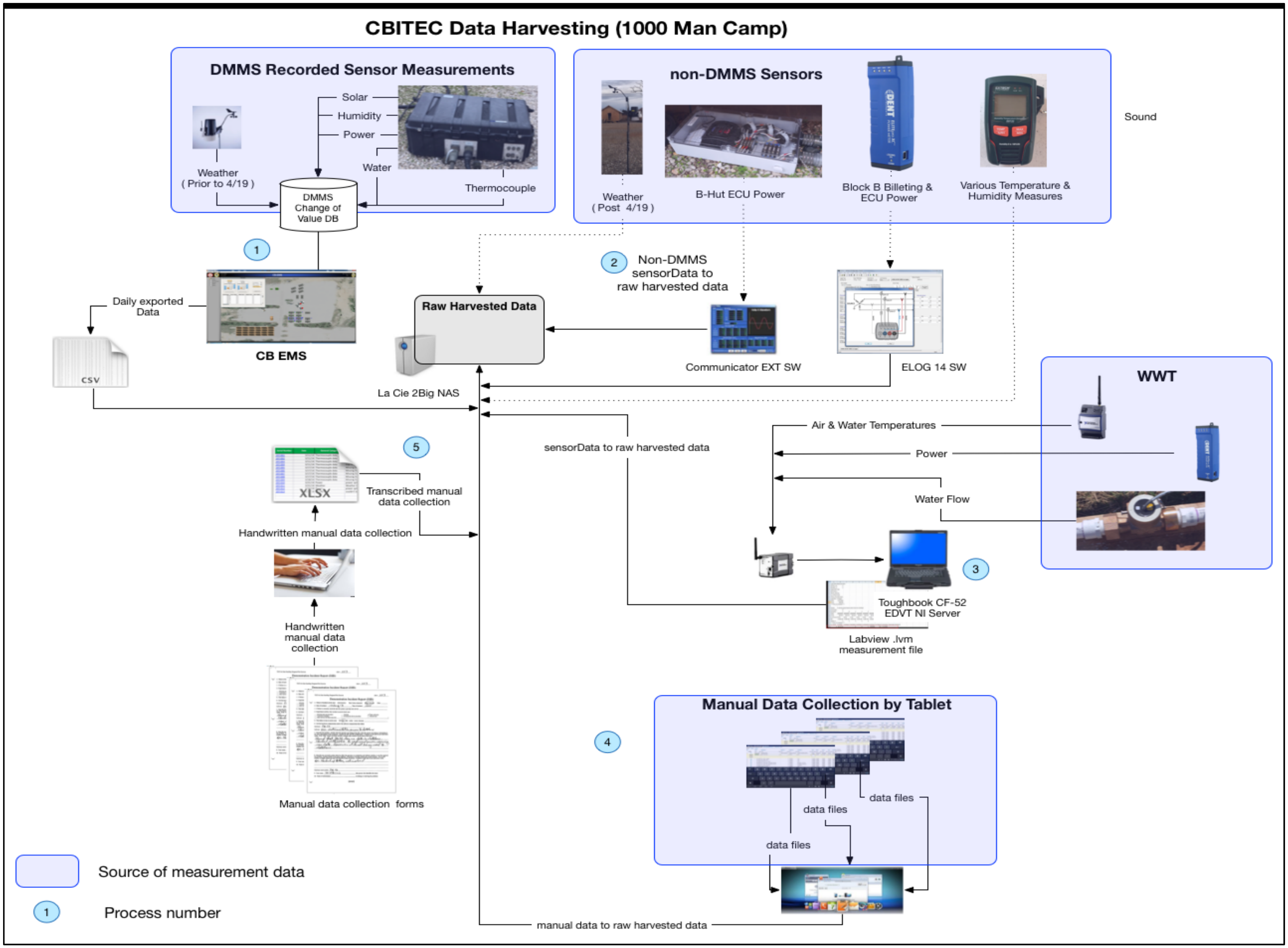


Figure 93: Data Harvesting

4.11.4 General Data Reduction and Processing

Once harvested, the raw data needed to be reduced and processed into deliverable data sets. Data sets were reduced to include only the data required by the DSM even though additional data might have been collected. The raw harvested data, described in the previous section, was not yet ready for review by the EDVT, or authentication by the DAG, in its raw harvested form. Many of the harvested data files contained either multiple sensors' worth of data packaged into a single file or multiple measures from a single sensor. These files required additional processing to structure them into the proper format for review and authentication.

For example, a single export file from DMMS contained every sensor that DMMS recorded for a given technology whether the sensor was of interest to the EDVT or not. Including extraneous data in the export files was done on purpose to ease the burden of extracting data from the DMMS database. Additionally, some technologies have multiple files worth of sensor data that need to be combined in order to make sense of the data. The WWT-Bio, for example, had power data contained in files generated by DENT power meters, but the water and air temperatures were in different files generated by the EDVT's National Instruments data.

4.11.4.1 Deliverable Data Set (DDS) Workbook

New for this demonstration was the introduction of a new DDS workbook for each technology. Feedback from the 50-Person Base Camp demonstration provided the EDVT with an insight that the previous model of delivering individual files was burdensome to the analysts and modelers and that a consolidated document that provided the data in context of the demonstration would be more useful.

In order to generate these workbooks, updated post-harvesting reduction and processing software worked with the various types of raw data files using the harvested data as an input, and a technology specific software module representing the requested data elements in the DSM represented the output. With these presets, the process control module (shown as Process 1 in **Figure 94**) generated a DDS workbook; one workbook per technology per day. Each of the generation processes is shown in **Figure 94**, where each subsequent process after the control process is a process specific to a demonstration technology. Manually collected data, and any other relevant data, was manually inserted into the appropriate workbook prior to its review. Once the workbooks were deemed complete and ready for review, they were stored in the Dashboard Ready section of the EDVT's NAS (shown in **Figure 94**).

4.11.4.2 Data Review Dashboard (DRD)

The EDVT used a custom visualization tool, the DRD, to review data prior to presenting it to the DAG and again at the DAG to show the data to the members. The DRD is shown in the upper right corner of **Figure 94** and was modified prior to the demonstration to be able to read the new DDS workbook format. Following review of the data, it was delivered to the DAG Chair where it was held for review by the DAG. The DAG and the data are represented at the top left and center of **Figure 94**. The data are shown only once to indicate that it is the same data reviewed internally and presented to the DAG. The DAG is discussed in greater detail in Section 4.11.5.

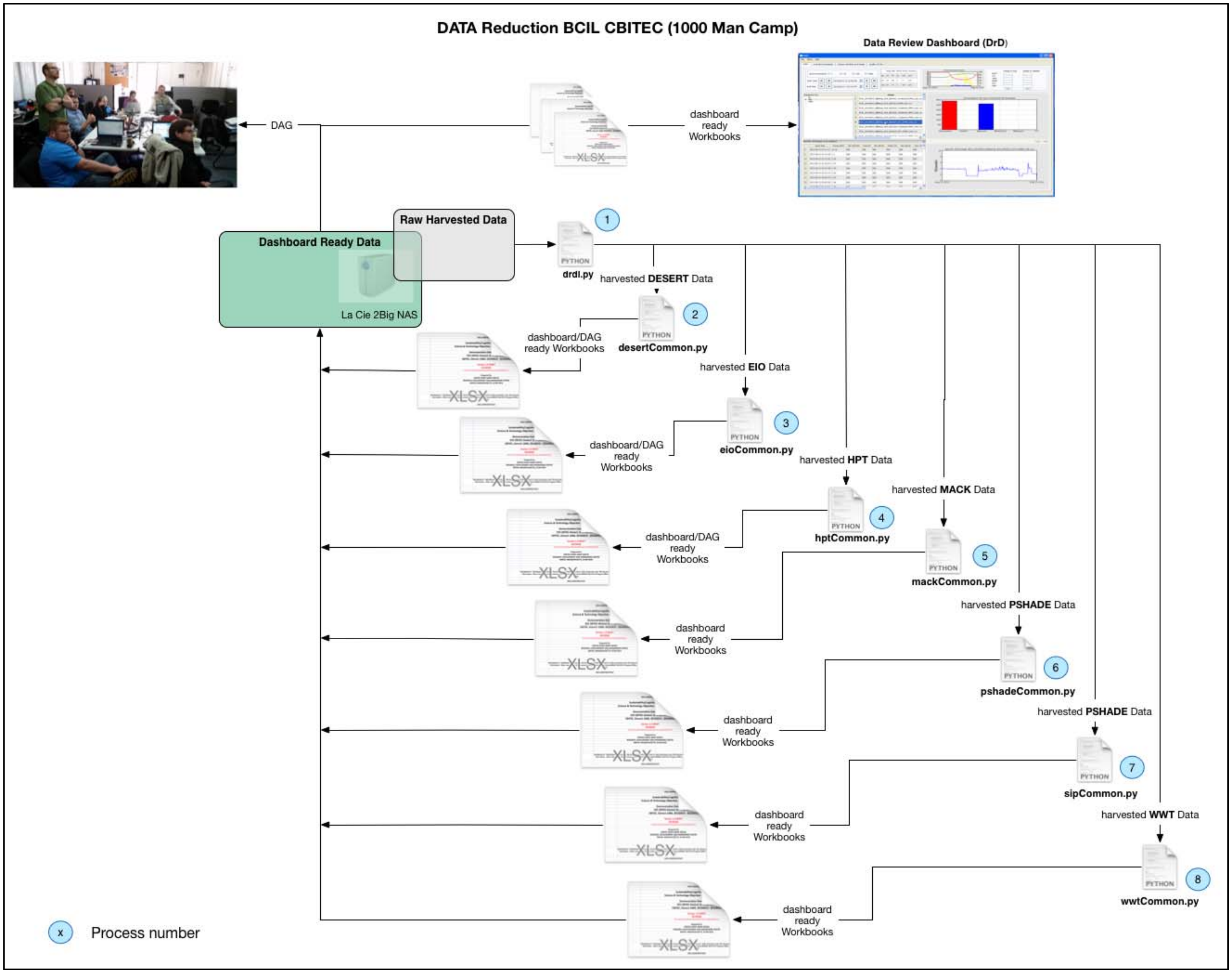


Figure 94: Data Reduction and Processing

4.11.5 Data Authentication and Delivery

Several meetings of the DAG were convened to authenticate the collected data. These meetings were conducted according to the established DAG Standard Operating Procedures. All but the last session were conducted on-site at CBITEC. One final meeting was conducted at NSRDEC to review WWT-Bio data. During the DAG meetings the voting members from each of the functional teams – CLT, TMIT, SEIT, RIT, EDVT, and MSAT – reviewed the data to ensure it accurately reflected the component and system performance during the demo. SMEs were on hand to answer questions. Good data were scored as “authenticated”. Questionable data or data requiring clarification were flagged for further investigation by the EDVT. Detailed minutes for each DAG session were prepared and distributed immediately following each meeting.

After the DAG meetings were completed, the EDVT investigated and resolved the flagged data. The authenticated data files were then compiled, cataloged, and delivered to the SLB-STO-D Lead Systems Engineer. This compilation included generating logs and notes to accompany the delivered dataset so that it could be usable by any number of end users. The complete Data Catalog is shown in **ANNEX E**.

5. RESULTS AND DISCUSSION

This demonstration was a huge success in many areas, and reinforced much about what the project team has learned in terms of planning, preparation, and execution. Much data was collected, and the majority of it is very useful. There were some areas identified as "needs improvement," but overall the project team and candidate technologies met the demonstration objectives. Operationally, the EIO-C system was able to power the A-block billets for the entire occupation of the MP BOLC class without loss of power. The MACK demonstrated its ability to save power using fuel-fired appliances in the successful execution of three field feeding events. In addition, the WWT-Bio continuously processed blackwater at the treatment facility for nearly 2 months.

Data findings and selected observations for each of the candidate technologies and the functions of data management, and the outcomes of Soldier training are documented in Sections 5.1 through 5.10. A summary of discussions, most of them in DAG meetings held before, during, and after demonstrations to assess the efficiency and accuracy of the data management processes associated with the field demonstrations are presented chronologically in **ANNEX F**.

5.1 MACK Results

The MACK demo was a great success, both technically and operationally. The field feeding operation was a major training event at Fort Leonard Wood and received much attention from the post and the media. A summary of the technical data for the three feeding exercises is shown in **Table 16.** It is evident that the kitchen consumed very little electrical power in the preparation of the meals. Much of the electrical power was for lighting and the on-board refrigerator. The majority of the energy required for cooking was provided by the JP-8 fuel in the appliances.

Feedback from the Soldiers on the performance of the system is documented in a separate report and included here in **ANNEX D, Appendix D.2**.

Table 16: Energy, Fuel and Water Data for Meal Preparation

MACK Demo	17-Apr	21-Apr	22-Apr
number of meals prepared	200	800	100
electrical energy consumed		kWh	
(0600-1500 hours)	2.06	2.19	1.53
fuel-fired appliance		lbs JP8	
left griddle	2.10	6.88	0.93
middle griddle	2.11	5.79	0.89
right griddle	2.29	7.28	1.03
left skillet	0.85	4.25	1.85
middle skillet	2.48	7.88	4.74
right skillet	5.40	7.71	2.84
right oven	2.90	7.97	1.22
left oven	0.52	8.54	2.94
serving line	2.69	(nm)	2.35
left MBU	(nm)	(nm)	(nm)
middle MBU	(nm)	(nm)	(nm)
total lbs JP8	21.34	56.31	18.79
total gallons JP8	3.18	8.39	2.80
water usage		gal water	
clean griddles	(nm)	8	(nm)
skillets, steam table, coffee	(nm)	25	20
cold drinks	(nm)	85	(nm)
Field Sanitation Center	(nm)	105	(nm)
(nm) = not measured			

5.2 DESERT Results

The DESERT was able to maintain its internal temperature during normal operations and during preparation for the field feeding operation for 800 Soldiers. **Figure 95** shows only a few very brief spikes in the internal temperature of the refrigerated section during a period of many door openings to prepare rations for the field feeding operation. The DESERT quickly recovers. Temperature data were measured at the bottom right corner in the front compartment during a day of normal operations (14 Apr) and the day before the 800-person field feeding event (21 Apr).

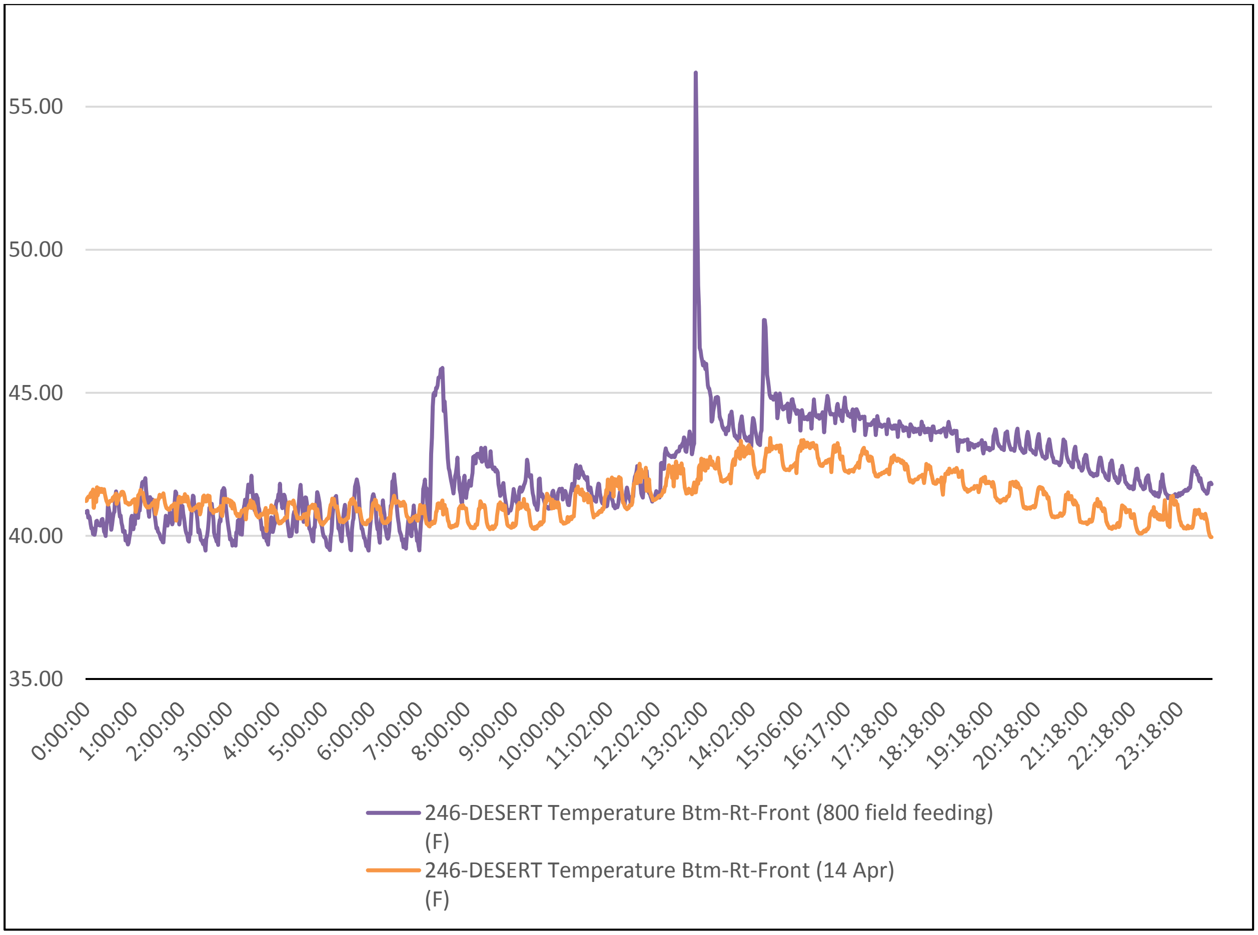


Figure 95: DESERT Internal Temps During Operation

The freezer compartment required some configuration updates to control icing of the fins and defrosting. On 17 April, it was found that the freezer could not recover the -5° setpoint after transferring meals from freezer to refrigerator and putting ice in the freezer (**Figure 96**). SunDanzer defrosted the freezer and modified the defrost algorithms. The freezer was then able to maintain its setpoint during normal operations on 20 April. On this particular day, the remaining food was removed from the freezer and the setpoint was adjusted from -5° to 5°. This is evident in the graph. Temperature data were measured at the bottom right corner in the rear compartment.

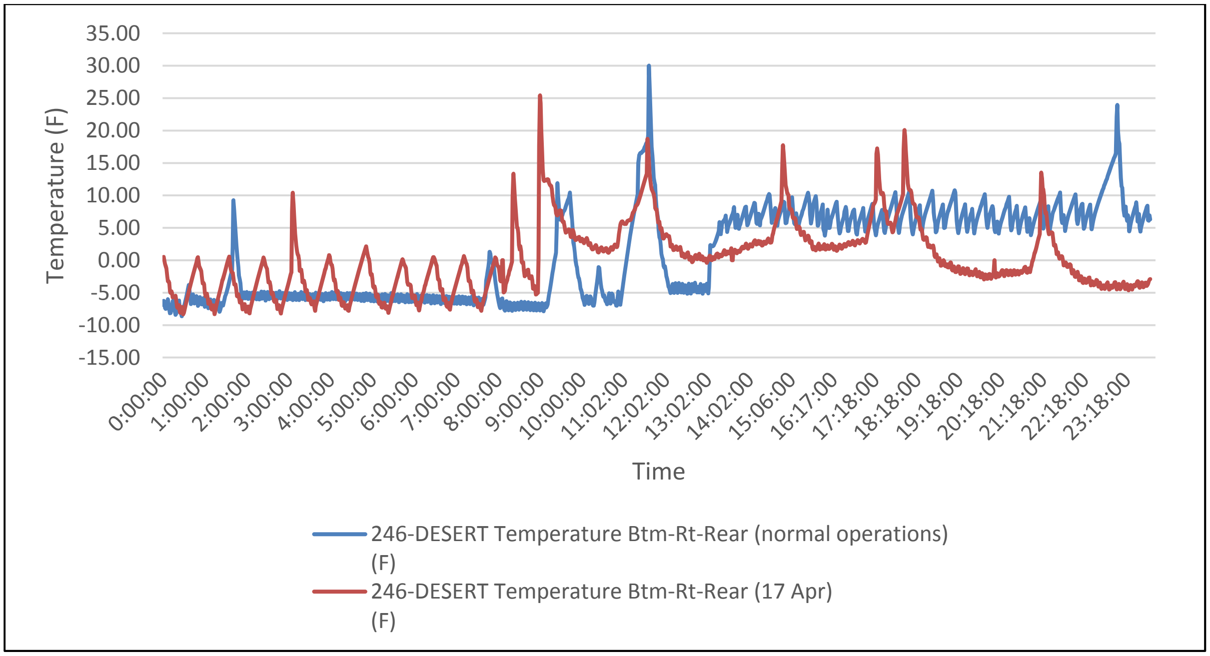


Figure 96: DESERT Internal Temperatures During Defrost

As noted earlier, it was not possible to install the solar shade over the DESERT due to the terrain. However, data was collected on the efficiency of the shade by collecting solar readings above and underneath the shade. A sample of these results is shown in **Figure 97.**

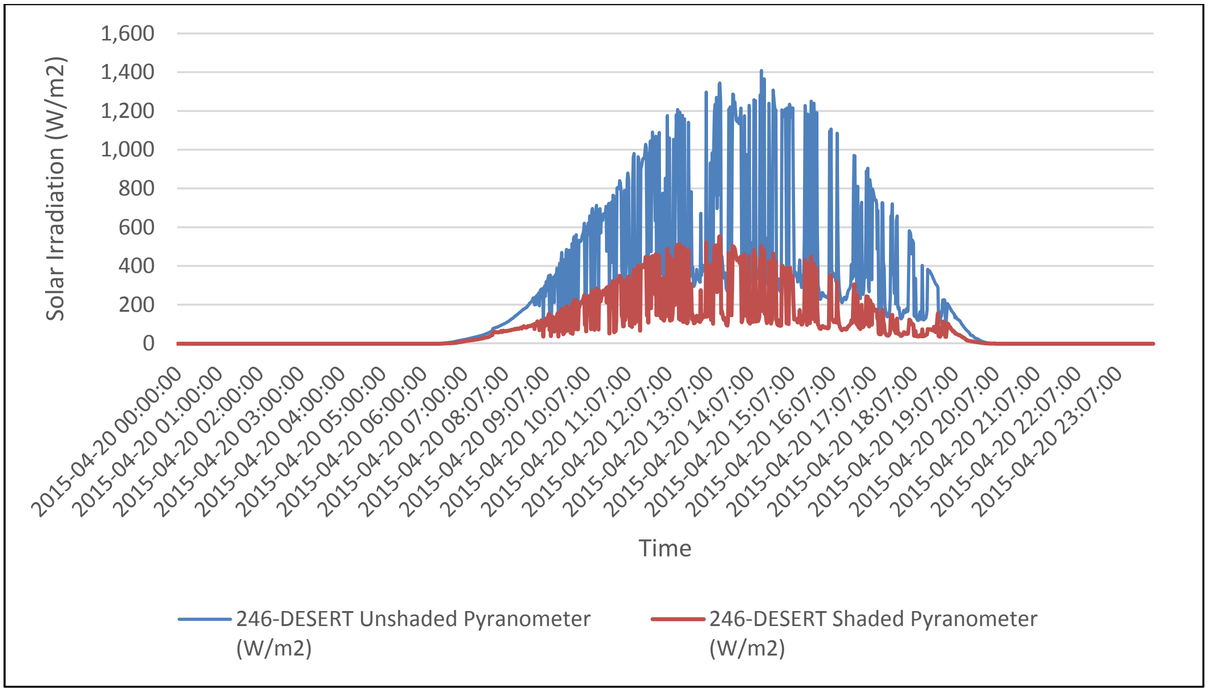


Figure 97: Solar Measurements Above and Underneath the DP2

The DESERT performed well. The analysts have the power figures to assess power and energy savings. As a result of the extensive field demo, SunDanzer identified three areas in which to focus further investigation and/or maturity – low refrigerant pressure switch settings, defrost duration in high humidity conditions, and switch from cooling to heat to maintain set-point temperature.

5.3 WATERMON Results

The WATERMON employed in this demonstration was a commercial surrogate. The WATERMON demonstration afforded the project officer the opportunity to conduct a proof-of-concept exercise in the field integrated with a working, developmental water treatment system. The employment of the WATERMON showed how the unit occupying a camp could evaluate the efficiency of its water treatment system in real-time and support decisions on disposition of the treated water.

The data from the WATERMON system were collected and submitted by the TARDEC project officer. **Figure 98** shows the historical summary of pH and temperature for both the inlet and the outlet, and dissolved oxygen for the inlet. **Figure 99** shows the historical summary of turbidity and total dissolved solids for both the inlet and outlet.

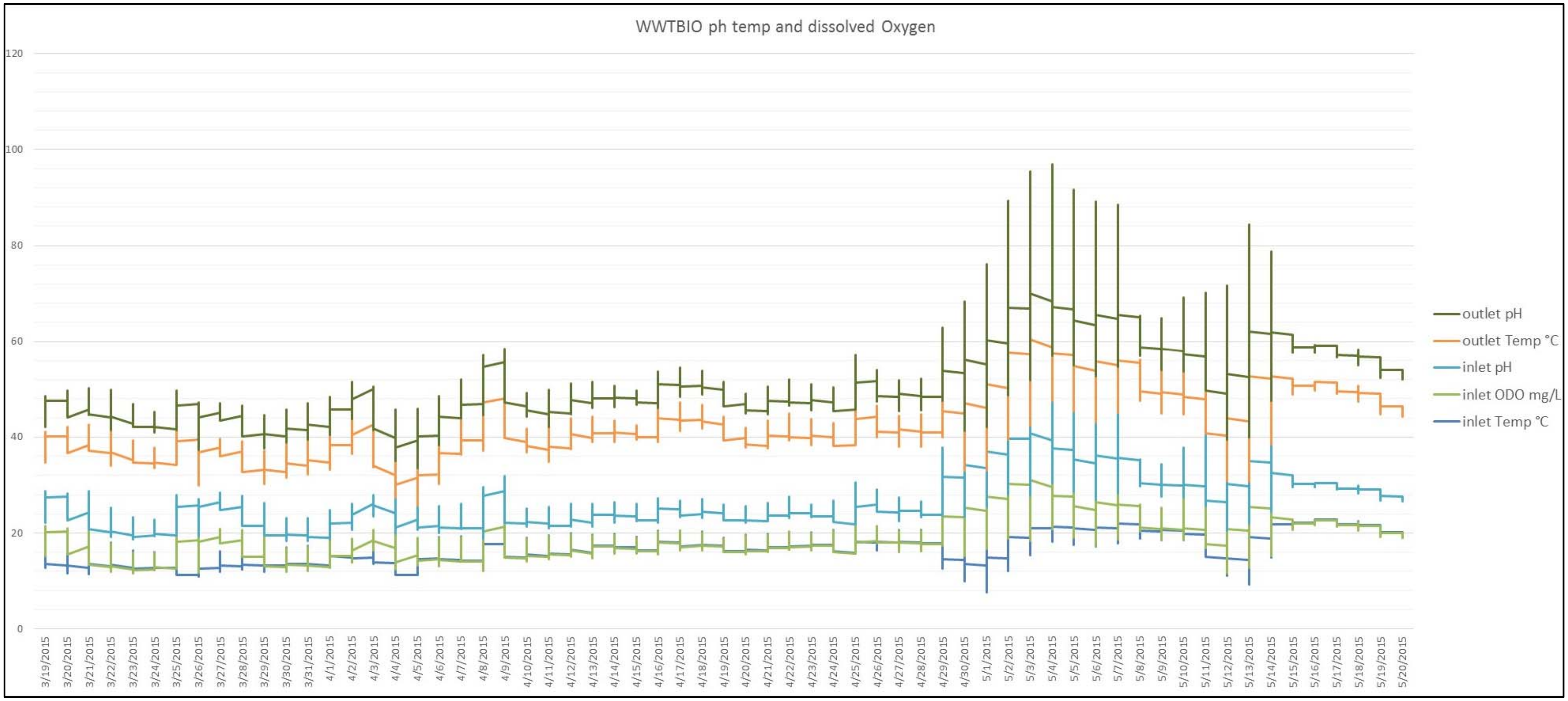


Figure 98: WATERMON Results for pH, Temp, and Dissolved Oxygen[5]

[5] These are raw data points and may include periods when then the Sonde was being calibrated or relocated. These points would be discarded prior to any analysis of the data. pH is reported in millivolts.

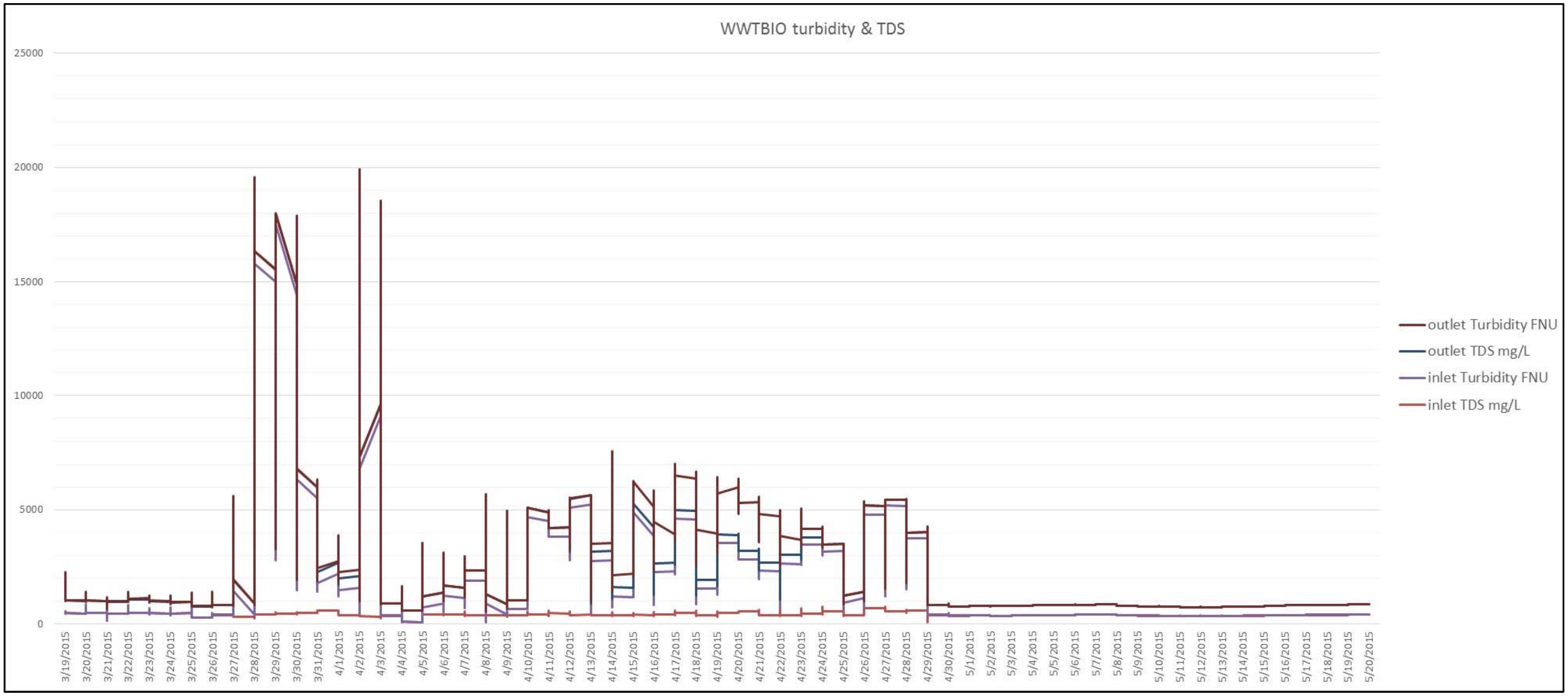


Figure 99: WATERMON Results for Turbidity and Total Dissolved Solids

5.4 WWT-Bio Results

The WWT-Bio was a long-term demonstration spanning a couple of months. The EDVT collected power data over this period. Some of the interesting events and trends are explained below.

Figure 100 shows the power profile for the system just a few days after the set up. It can be seen that the power required was close to 2kW to operate the pump and blowers in manual mode. The gaps in the midday range are when the maintainer turned the system off to install instruments.

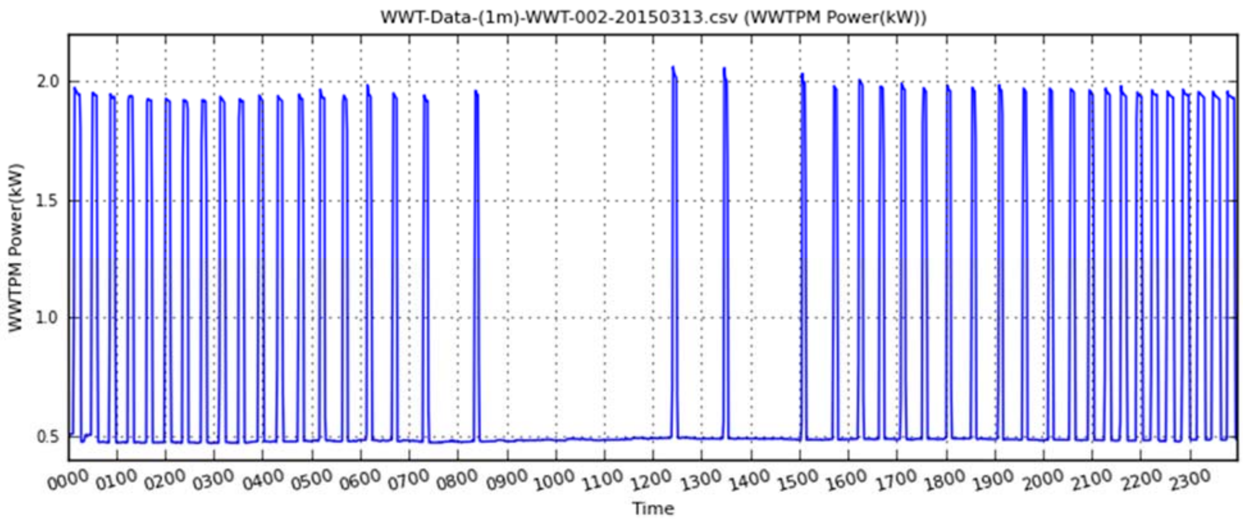


Figure 100: WWT-Bio Power Data at Start of Demo

Figure 101 shows the power profile after the DO sensor was installed. The main blower is controlled by the DO level. The pump was still operated at a 30-min ON and 30-min OFF pattern.

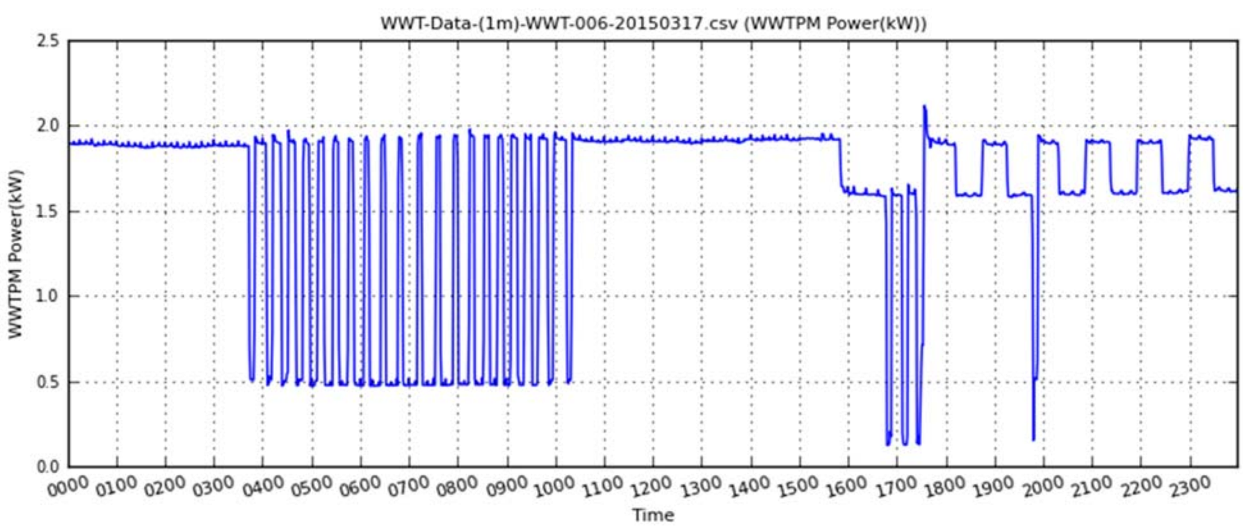


Figure 101: WWT-Bio Power Data after DO Sensor Installed

Figure 102 shows a typical power pattern for the WWT-Bio. The main blower is controlled by the DO sensor. When the pump and the main blower were on at the same time, the power use was close to 2 kW. When the main blower was on and the pump was not on, the power use was 1.7 kW. When the pump and the maintenance blower were on at the same time, the power use was 0.5 kW, and when the maintenance blower was on, the power use was only 0.2 kW.

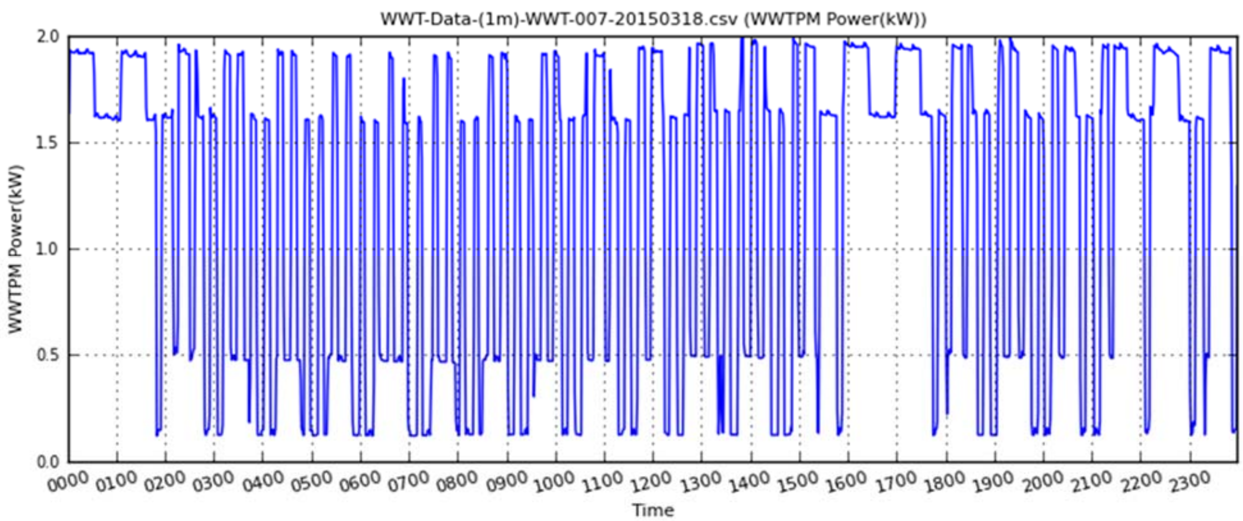


Figure 102: WWT-Bio Power Data Typical Pattern

Figure 103 shows a sustained condition of higher power use after 1300 hours. The vendor suggests this could be due to a higher strength of influent during this period. This particular day was a Saturday. The following day, Sunday, showed the same pattern after noon.

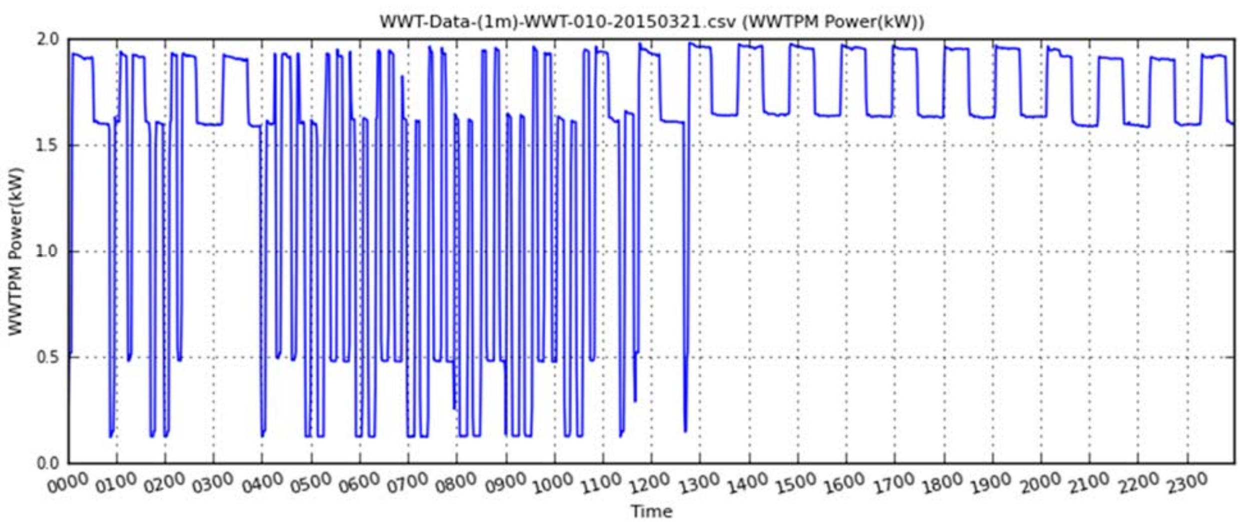


Figure 103: WWT-Bio Power Data When Influent Strength Increases

Figure 104 shows the power pattern when the influent strength decreases. Indeed, historical data shows that there was a rain storm on 25-26 March and the water runoff would have diluted the wastewater stream to the plant.

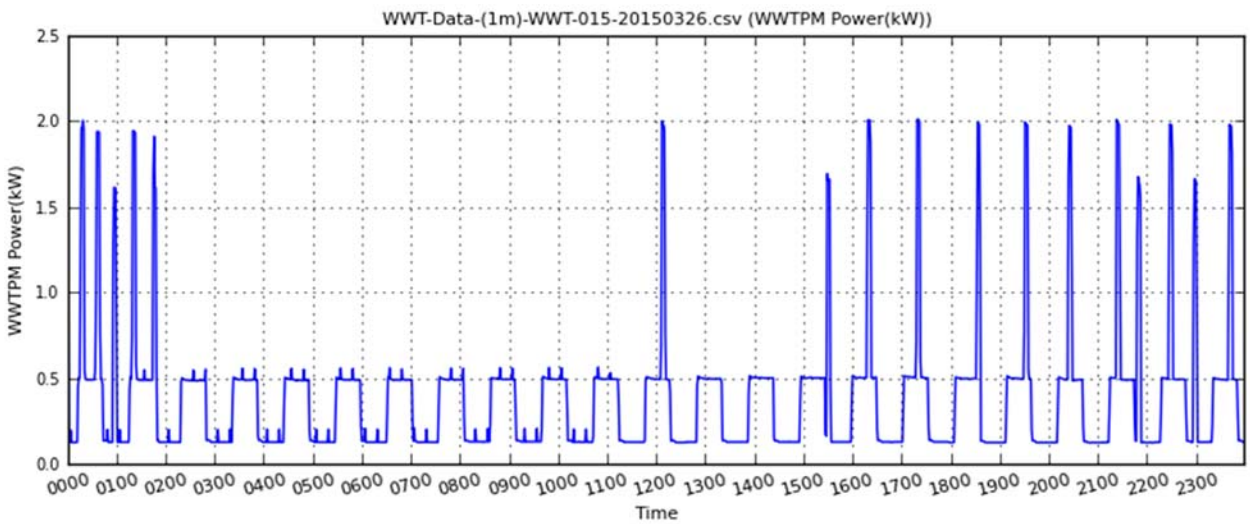


Figure 104: WWT-Bio Power Data When Influent Strength Decreases

Figure 105 shows the power pattern when the throughput rate of the system is doubled from 3000 gal/d to 6000 gal/d.

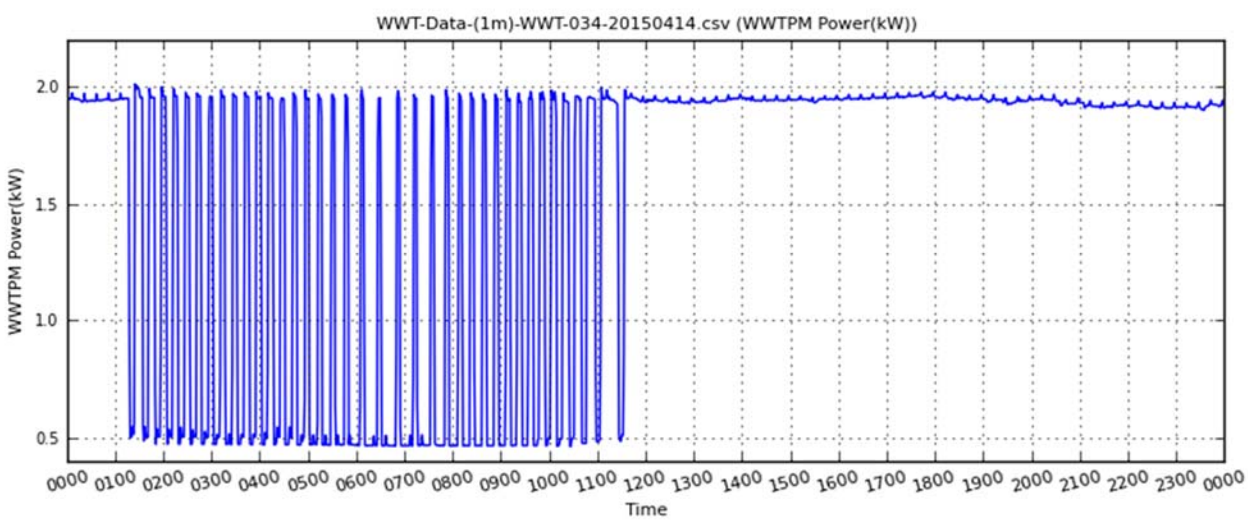


Figure 105: WWT-Bio Power Data When Throughput Is Doubled

5.5 PSHADE Results

The PSHADE contributes two capabilities – first, it shades the shelter underneath, thereby making the shelter easier to cool in warmer climates, and second, it generates power for use in the shelter. **Figure 106** shows a sample of the solar irradiation measured on top of the PSHADE (red line) and underneath the PSHADE flap (blue line) over a 24-hour period. These data give an indication of the shading efficiency of the system.

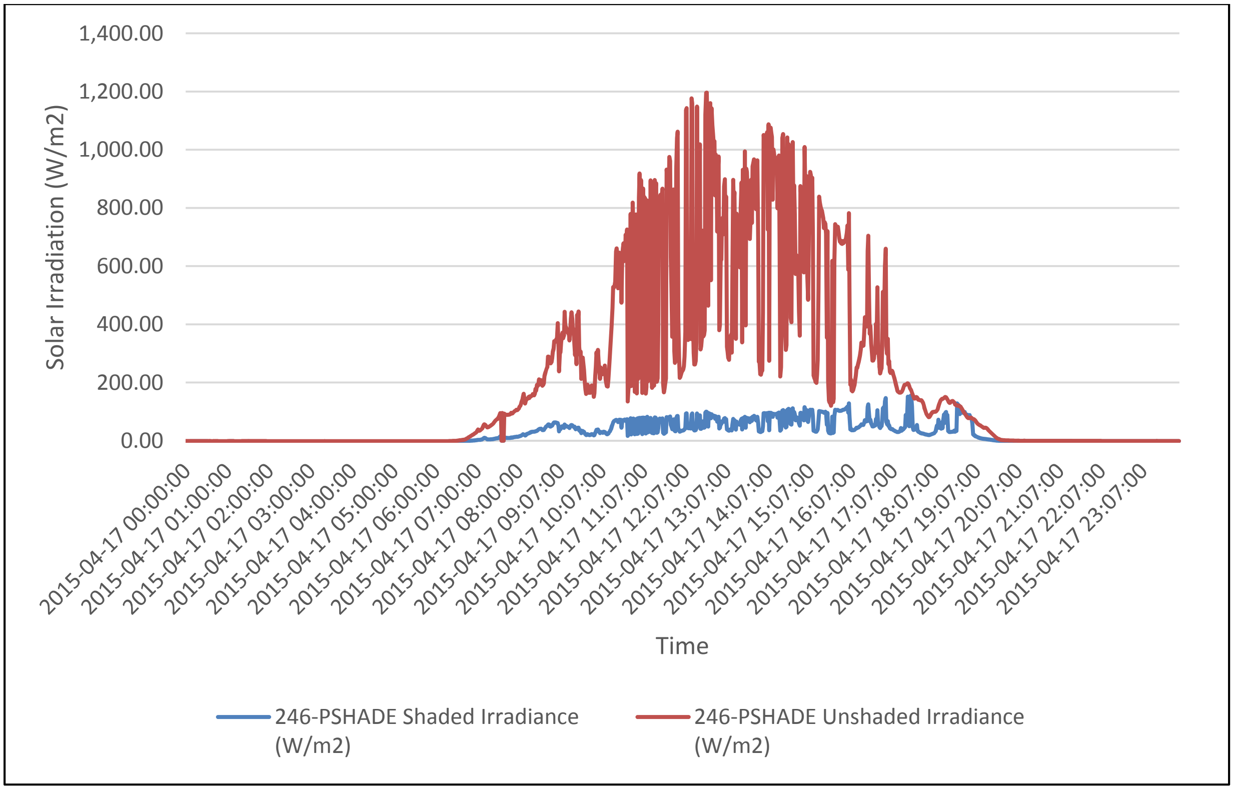


Figure 106: PSHADE Irradiance - Shaded vs Unshaded

The following figures show the performance of the PSHADE in generating electricity. **Figure 107** shows the amount of sunlight on the shade[6].

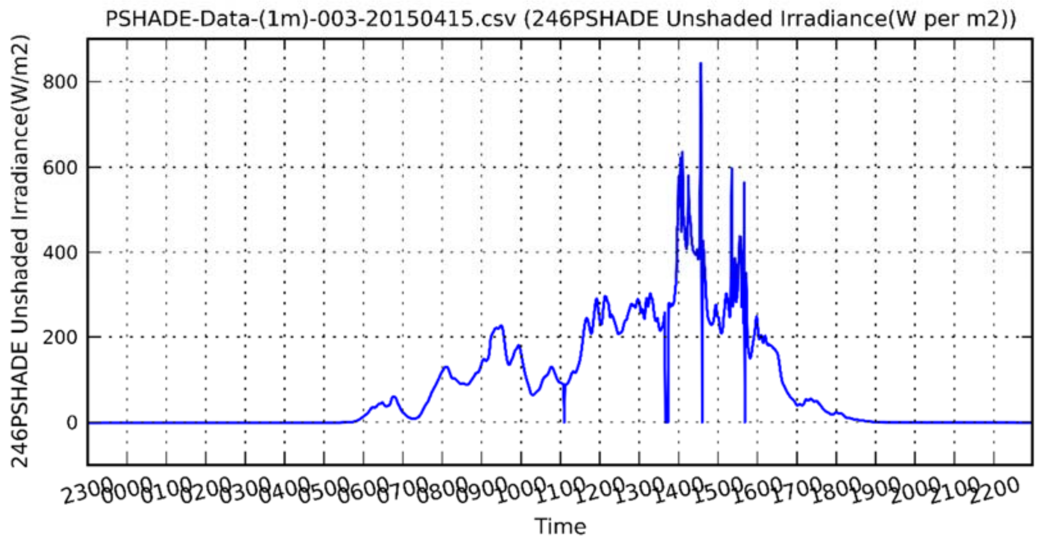


Figure 107: Unshaded Irradiance over PSHADE

[6]There are occasional points in the following data where values drop to zero. These points are data collection artifacts and likely due to wireless communications issues.

Figure 108 through **Figure 111** show the corresponding current generated in the four independent legs of the system. The relationship between the amount of solar radiation (**Figure 107**) and the current can be seen. The magnitudes of the current are slightly different for each drop. This is likely a function of the slight differences in orientation of each PV array.

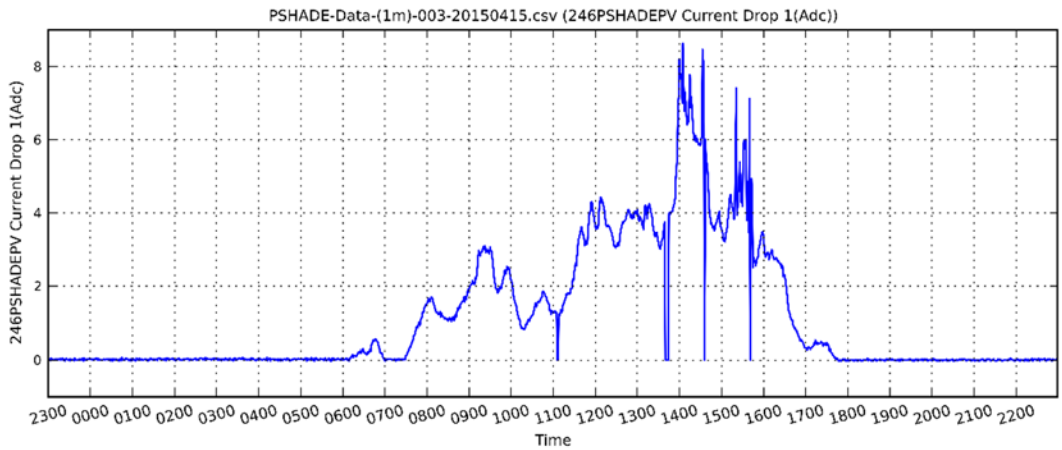


Figure 108: PSHADE Current Drop 1

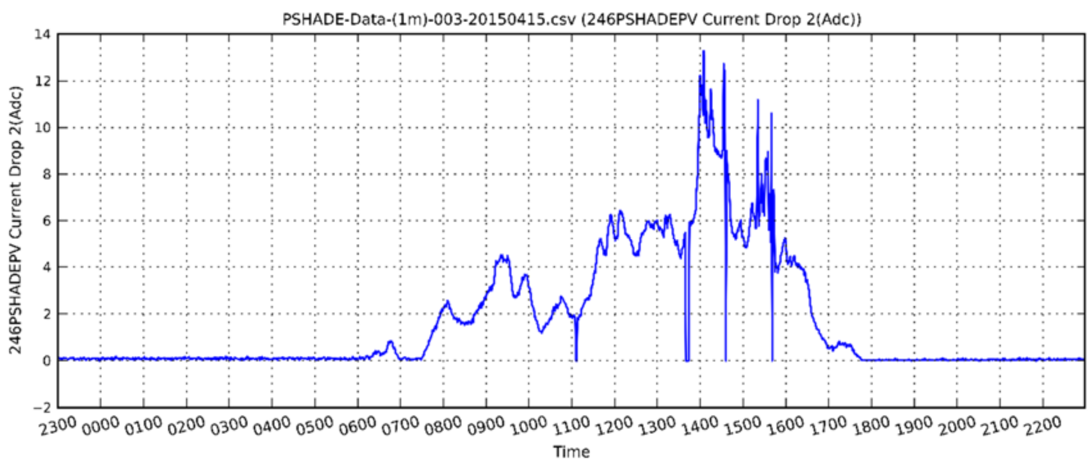


Figure 109: PSHADE Current Drop 2

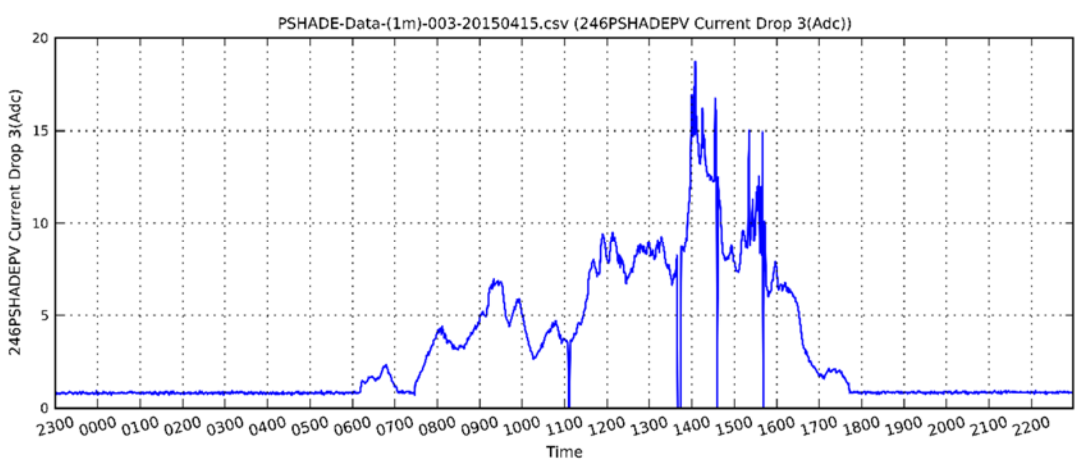


Figure 110: PSHADE Current Drop 3

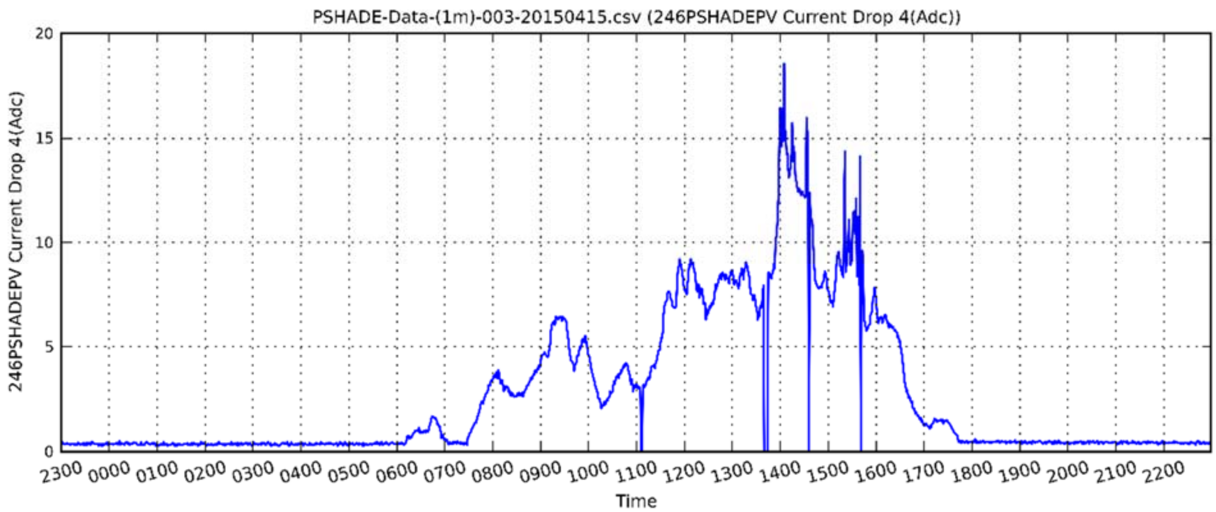


Figure 111: PSHADE Current Drop 4

The corresponding voltage is shown in **Figure 112**. It is important to note that the voltage sensor was not working before 1220 hours. Also, the vendor confirmed that the voltage seen after sunlight hours is due to backfeed from the batteries. The other three voltage drop graphs (not shown here) are very similar.

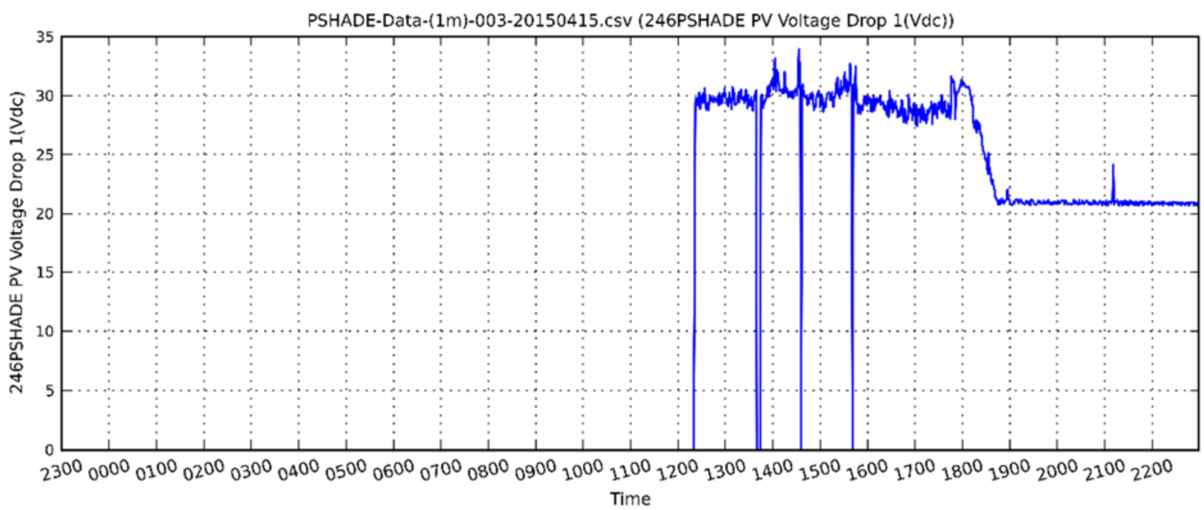


Figure 112: PSHADE Voltage Drop 1

Figure 113 and **Figure 114** are the power data from the load in the shelter. The BOS1 powered the lights in the shelter, while the BOS2 powered the ECU and the electronics used for the display.

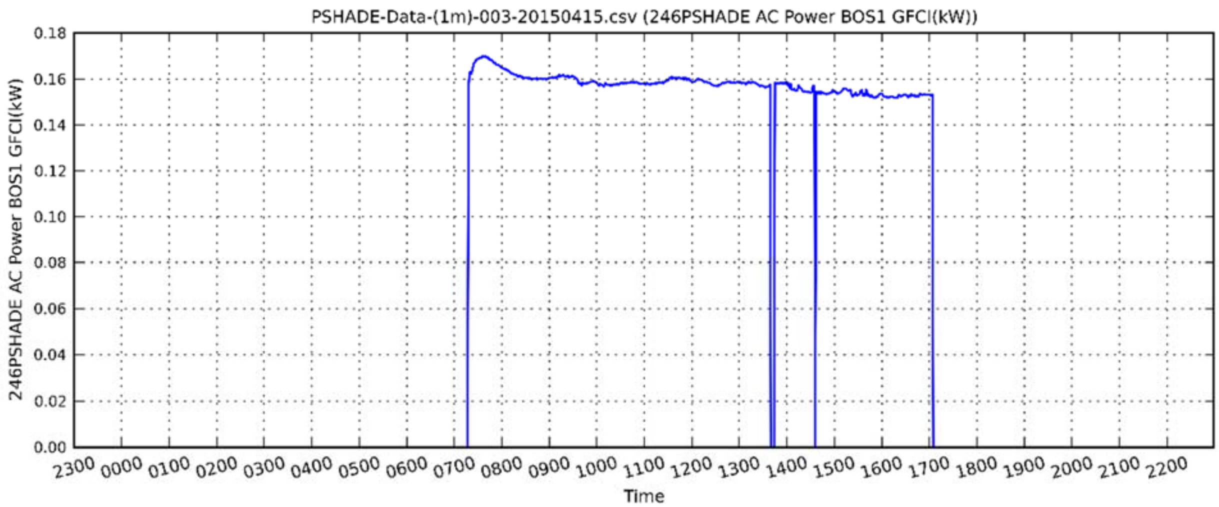


Figure 113: PSHADE BOS1 Load

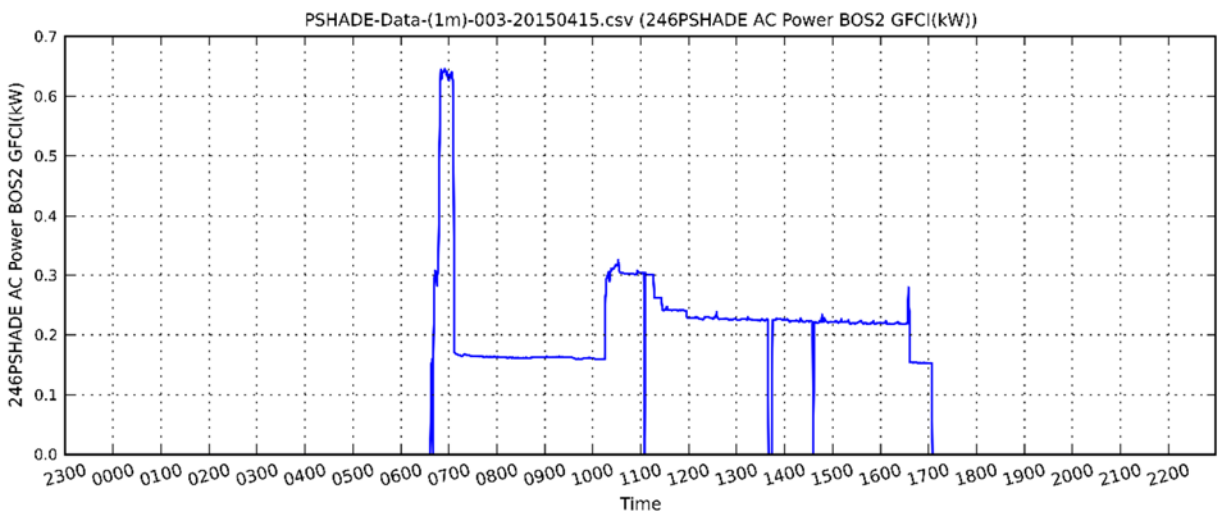


Figure 114: PSHADE BOS2 Load

5.6 EIO-C Results

The EIO-C successfully powered the grid for the duration of the occupation by the MP BOLC class in the A-block B-Huts. This required 24/7 monitoring of the power systems and CERDEC provided that service. Prior to the operational demo with the Soldiers, there was an opportunity to run scripts developed by the SEIT to demonstrate the functionality of the EIO-C grid.

Table 17 details the script run on 13 April.

Table 17: EIO-C Script

April 13, 2015 B-HUTS A-H (EIO-C A-Grid) TQG #3 & TQG #4		
Time	**HUTs**	**IECU**
1000	A-H	Heat Max
1030	A-B	Vent
1100	G-H	Vent
1130	E-F	Vent
1200	C-D	Vent
1230	A-H	Cool Max
1300	A-B	Vent
1330	C-D	Vent
1400	E-F	Vent
1430	G-H	Vent

Figure 115 is a screenshot of the EIO-C app dashboard that shows the power capacity of the EIO-C and the active loads. ECUs for all eight huts in the A-block were set to max heat at 1000 hours. Then every 30 min, two of the ECUs were switched to vent, thus decreasing the power demand. Then at 1230 hours, all ECUs were set to max cool, increasing the power demand. Then every 30 min, two ECUs were again switched to vent. It can be seen in the power graph that during periods of higher demand each of the two 60kW generators were turned on to service the load. When not needed, the "droop" generator was turned off to save fuel.

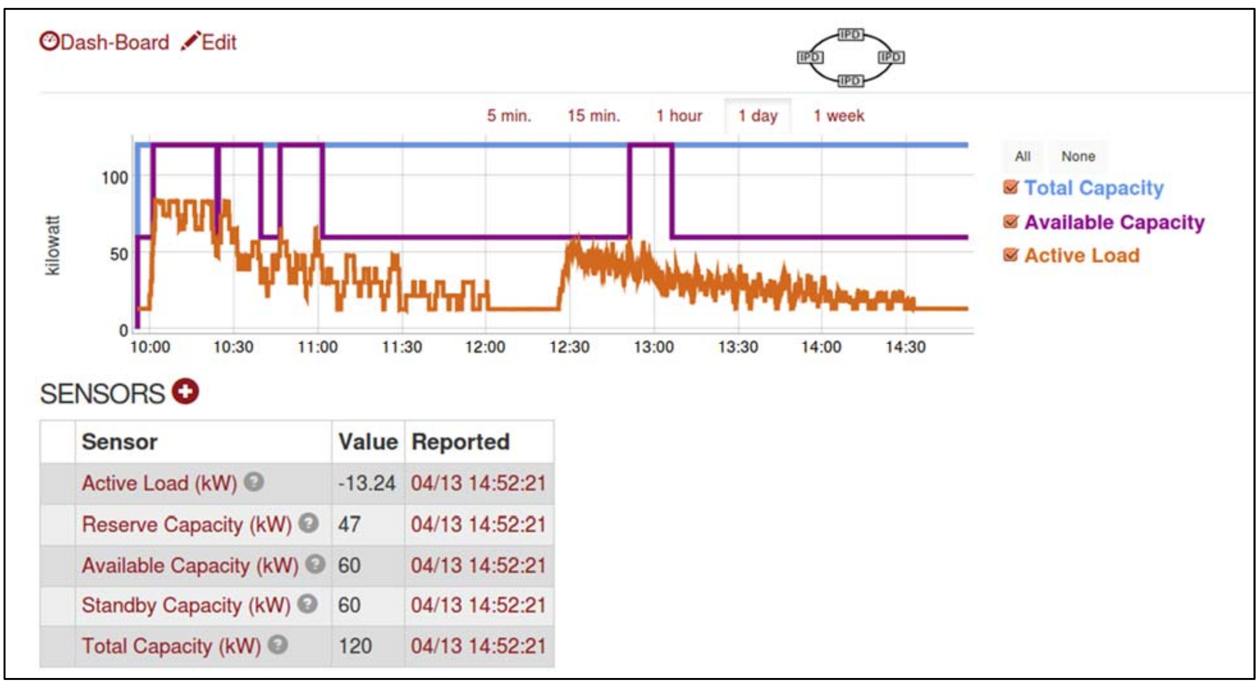


Figure 115: EIO-C Power Generation During Script on 13 April

Figure 116 and **Figure 117** are power graphs for similar scripts on 14 and 15 April. In each graph it can be seen that the droop generator is powered off when not needed.

SENSORS

	Sensor	Value	Reported
	Active Load (kW)	-13.5	04/14 14:41:56
	Reserve Capacity (kW)	47	04/14 14:41:56
	Available Capacity (kW)	60	04/14 14:41:56
	Standby Capacity (kW)	60	04/14 14:41:56
	Total Capacity (kW)	120	04/14 14:41:56

Figure 116: EIO-C Power Generation During Script on 14 April

SENSORS

	Sensor	Value	Reported
	Active Load (kW)	-13.65	04/15 14:55:40
	Apparent Power (kW)	15.34	04/15 14:55:40
	Reactive Power (kvar)	-6.68	04/15 14:55:40
	Reserve Capacity (kW)	47	04/15 14:55:40
	Available Capacity (kW)	60	04/15 14:55:40
	Standby Capacity (kW)	60	04/15 14:55:40
	Total Capacity (kW)	120	04/15 14:55:40

Figure 117: EIO-C Power Generation During Script on 15 April

5.7 DMMS Results

There were no data requirements for the DMMS, as it is a data acquisition system itself. The EDVT utilized DMMS to collect data per the instrumentation plan. There were a number of lessons learned upon using the DMMS for data collection, chiefly that a stable mesh radio network is essential to uninterrupted data collection. The PPS students were introduced to the DMMS tool and their comments are documented in **ANNEX C** and **Appendix D.1**.

5.8 HPT Results

The HPT provides a capability to store power from a generator so that excess power is not wasted. In this demonstration the HPT powered the MACK, provided supplemental power to the DESERT, provided a grid-tie for the PSHADE and display tent, and powered the electronics under the "Big Top" for the Stakeholder Day.

The following data are from 15 April. Operations and data collection on this day started at 0700 hours. **Figure 118** and **Figure 119** show the average amps and average voltage, respectively. There is an artifact in the data at 1050 hours that causes a drop to zero – this data point should be disregarded. This was likely the result of lost communication with the sensor. **Figure 120** shows the generator ON/OFF status. This is a little hard to see in this graph, but the generator was ON at the start of operations at 0700 hours. It ran for 1 hour to charge its battery and shut itself off at 0800 hours. The battery satisfied the load (**Figure 121**) all day. The generator automatically came back on again at 2045 hours to recharge the battery.

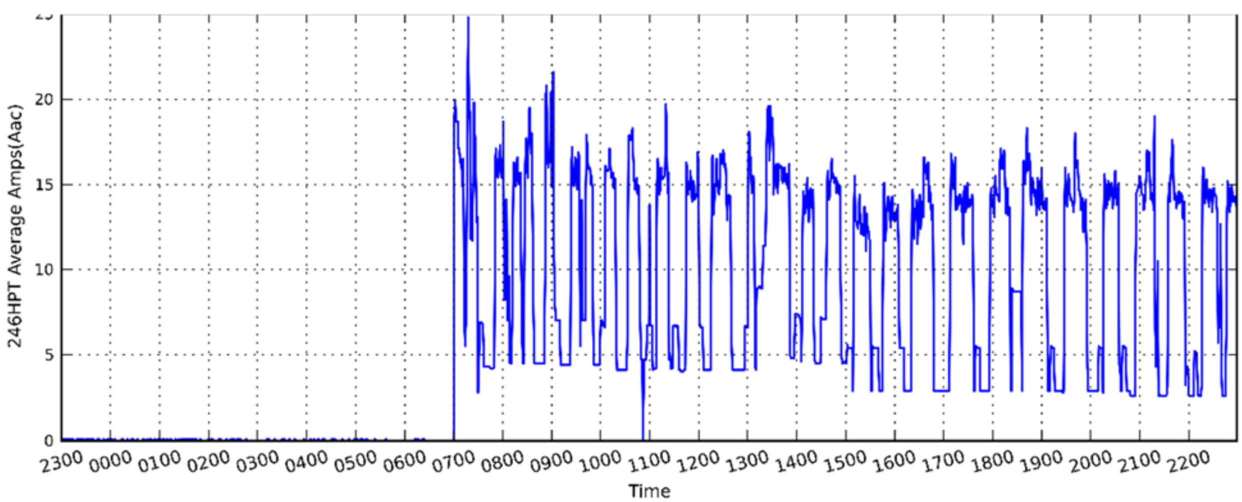


Figure 118: HPT Average Amps

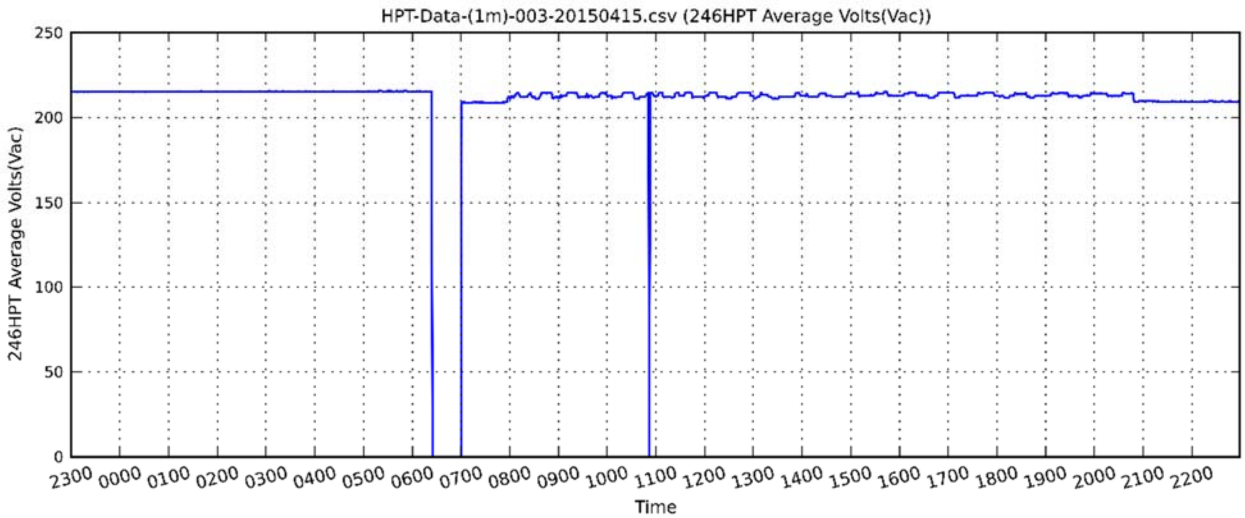


Figure 119: HPT Average Volts

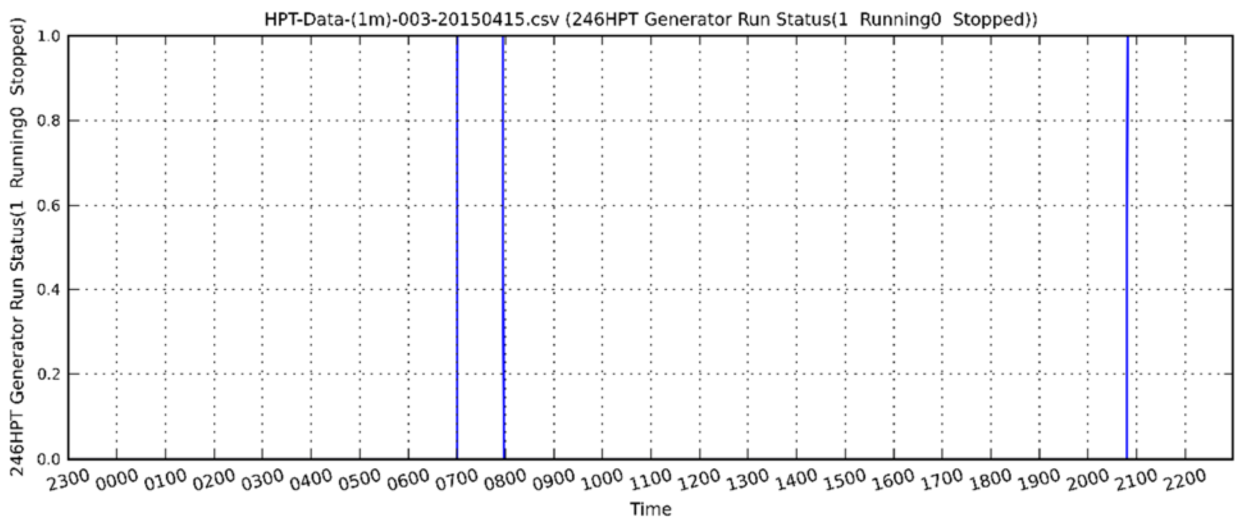


Figure 120: HPT Generator ON/OFF

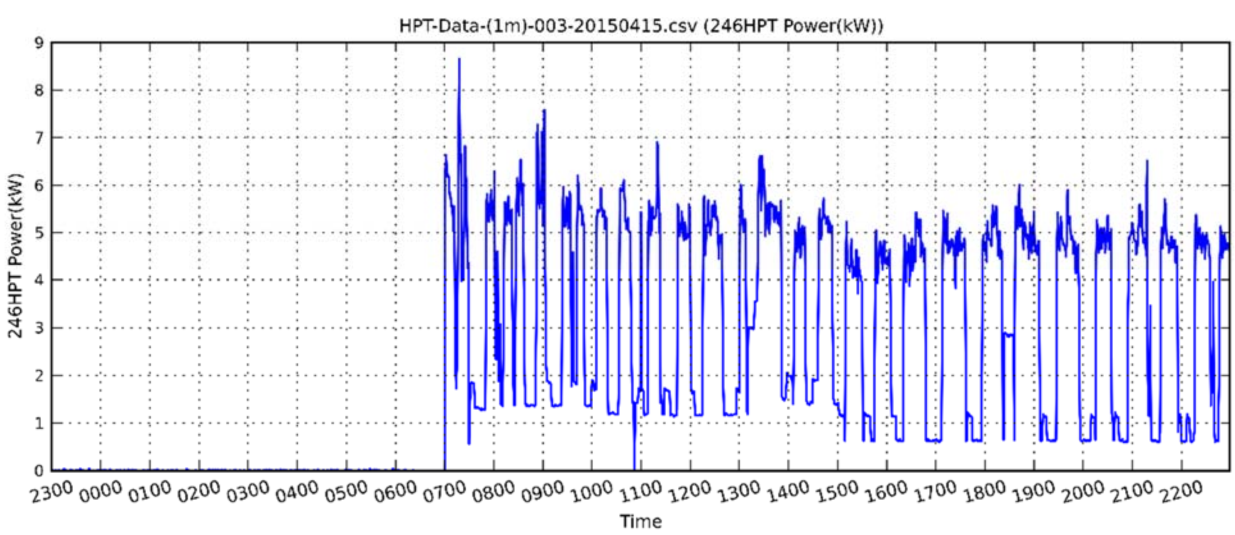


Figure 121: HPT Power

Figure 122 shows the power consumption and generator run time for 22 April, the Stakeholder Day. The HPT was running all night providing a baseline of power for the DESERT and MACK refrigerator. Then in the morning the cooks showed up to prepare the meal and the power demand increased. Shortly after 0900 hours, the battery was depleted enough that the generator was required. The generator ran until about 1630 hours and then was no longer needed the rest of the evening.

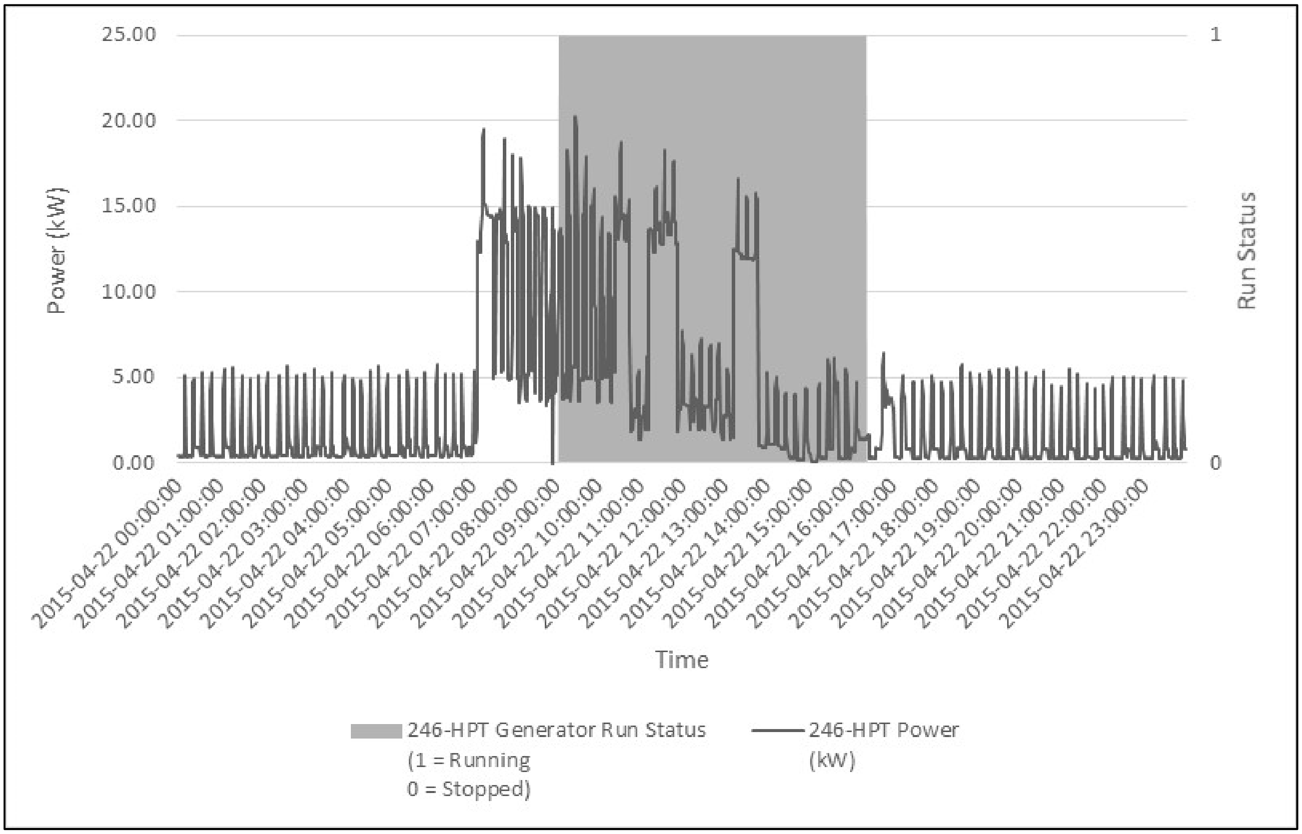


Figure 122: HPT Power Data on Stakeholder Day

5.9 SIP-Hut Results

The SIP-Hut is a very well insulated structure and requires little power to maintain its internal temperature once attained. This can be seen by looking at a day in which the ECU was switched from HEAT to COOL. **Figure 123** shows the power and temperature data from Saturday, 18 April, midnight to midnight. The ECU was left in low HEAT mode Friday night for data collection purposes. It can be seen that on Saturday morning, it required very little power, about one kW, to keep the internal temperature much warmer than the ambient (operationally, the ECU would have been turned off under these conditions and the power would not be used at all to maintain a comfortable temperature in the hut.) At 1243 hours, once the ambient temperature had started to climb significantly, the ECU was switched to low COOL mode. It can be seen that the ECU worked to bring the internal temperature down from about 84 °F to around 72 °F. It takes a little while to overcome the ambient temperature and the heat held in the structure, but eventually the ECU and hut are able to maintain the temperature with very little power. At 1845 hours, the

ECU is again switched back to low HEAT, and the internal temperature again rises with very little power required.

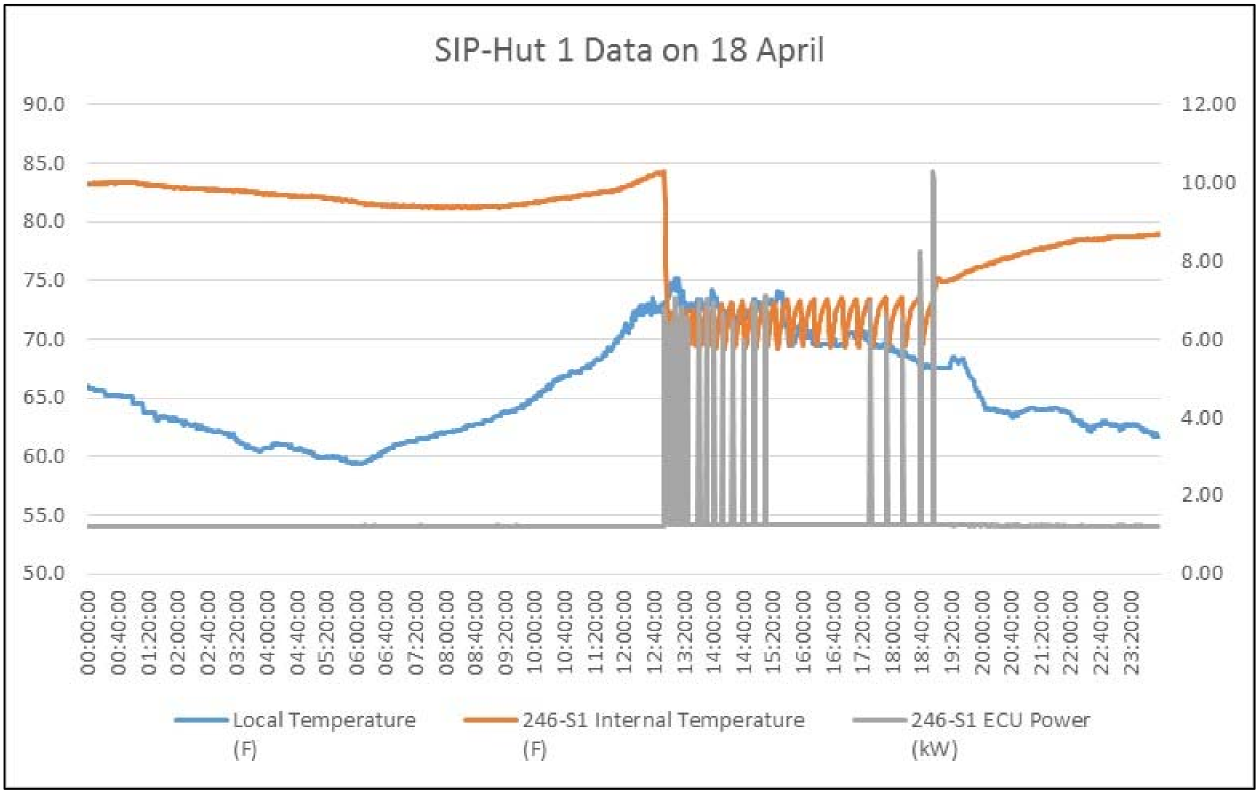


Figure 123: SIP-Hut Power and Temperature Profile

There were a number of instrumentation and data collection issues associated with characterizing the SIP-Hut. The SLB-STO-D will look for future opportunities to return to CBITEC and collect data on SIP-Huts and ECUs.

5.10 Soldier Training Feedback and Findings

See **ANNEX D** for reports on Soldier focus groups with the PPS and with the Food Specialists.

6. CONCLUSIONS

This demonstration at CBITEC was a significant success in many areas, and in some, there were a number of lessons learned.

- ✓ **Objective 1**: Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and support trade-offs and engineering decisions (main effort).

  This objective was met for most of the technologies. There were some, like the SIP-Hut and the PSHADE that could have benefitted from better instrumentation, refined scripts, or technical support.

- ✓ **Objective 3**: Collect data on Quality of Life at the camp.

  This objective was met by including Soldiers in training and focus groups. Empirical data was also collected to support the SLB-STO-D Quality of Life (QoL) tool, such as noise level, humidity, and temperature readings. Maintaining a quality of life is an inherent requirement of the SLB-STO-D challenge.

- ✓ **Objective 4**: Show how SLB-STO-D meets CB and OE gaps.

  This objective was met by demonstrating technologies that will save fuel and reduce the amount of waste generated at contingency base camps. Data collected from demonstration and presented in analysis conclusions have and will help inform related Capability Development Documents (CDD) and Capability Based Assessments (CBAs).

- ✓ **Objective 5**: Showcase any "Wow Factors," i.e., the materiel and non-materiel game changers.

  This objective was specifically included to ensure that any technology not meeting the strict Demonstration Entrance Criteria could be minimally assessed or given visibility at SLB-STO-D demonstrations. None were included in this demonstration; however, there may be some in upcoming demonstrations.

  This objective was met by demonstrating closed combustion burners and appliances in the MACK. Enclosed combustion appliances in the MACK are game changing attributes to QoL. The Soldier feedback detailed in **Appendix D.2** highlights the significant improvements for Army cooks. This technology received considerable attention from the post and the media during the demonstration. The Fully Burdened Cost Tool (FBCT) results presented during the demonstration suggest that fuel and particularly water reduction technologies have a very significant impact on reducing convoys and Soldier threat exposure hours associated with resupply operations. Additional insights to which technology areas are game changers in reducing fuel, water and waste will be documented in MSAT reports.

- ✓ **Objective 6:** Present modeling and simulation methods and results as part of the demonstration through visual and physical displays, such as posters and computer representations of models.

  Although not documented in this report, this objective was met during the activities of Stakeholder Day. The MSAT tools, current findings, and approach were presented to the key stakeholders in attendance and posters with many of these details were on display in the display tent during demonstration.

Congruent with the many successes, there were a number of tough lessons learned. Some of the issues are documented here for historical reference.

Technology Readiness – Some of the technologies were not as ready for the Integrated Field Demonstration Phase as would have been preferred. A number of technical issues were presented. Some were resolved in time to allow data collection, but some were not. The lesson learned is to encourage the candidate technologies to take full advantage of the Demonstration Prep Phase and get systems fully ready for field demonstration.

Instrumentation and Data Management – This was a challenge. The EDVT elected to integrate much of the required instrumentation with the DMMS backbone at CBITEC. This presented a number of challenges that took time to resolve. In addition, just the magnitude of the data management workload compared to the previous demonstration, without additional personnel with the proper training and skill sets, caused much of the team to work excessive hours to get the task done. On top of that, the EDVT instituted the deliverable workbook in response to requests for more and more information associated with datasets. This was a new process that took some refinement.

Integration of Technologies and Technology Support During Demonstration – Some of the technologies did not have dedicated or complete support during the demonstration. This became an issue when there were integration problems to resolve or when systems left behind were not operated under optimal data collection conditions.

The SLB-STO-D and EDVT will build on these successes and overcome the challenges in future demonstrations.

This document reports research undertaken at the U.S. Army Natick Soldier Research, Development and Engineering Center, Natick, MA, and has been assigned No. NATICK/TR- 16/027 in a series of reports approved for publication.

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LIST OF ACRONYMS

A2D	Analog to Digital
AAR	After Action Review
AC	Alternating Current
AK	Assault Kitchen
AMSAA	Army Materiel Systems Analysis Agency/Activity
ASD	Assistant Secretary of Defense
AV	Audio-visual
BAH	Booz Allen Hamilton, Inc.
BCIL	Base Camp Integration Laboratory
B-Huts	Barracks Huts
BOS	Balance of System
C2	Command and Control
CASCOM	Combined Arms Support Command
CB	Contingency Basing
CBITEC	Contingency Basing Integration and Technology Evaluation Center
CERDEC	Communications-Electronics Research, Development and Engineering Center
CERL	Construction Engineering Research Laboratory
CK	Containerized Kitchen
CK-I	Containerized Kitchen - Improved
CLT	Core Leadership Team
COP	Combat Outpost
COTS	Commercial-off-the-Shelf
CoV	Change of Value
CRT	Consumer Research Team
DAG	Data Authentication Group
DAMP	Demonstration and Assessment Master Plan
DC	Direct Current
DCS	Digital Control System
DDS	Deliverable Data Set
DESERT	Desert Environment Sustainable Efficient Refrigeration Technology
DFAC	Dining Facility
DIACAP	DoD Information Assurance Certification and Accreditation Process
DIR	Demonstration Incident Report
DIT	Data Investigation Ticket
DL	Data Librarian
DMC	Data Management Center
DMMS	Deployable Metering and Monitoring System
DO	Dissolved Oxygen
DOC	Demonstration Operations Center
DP2	DESERT Power 2
DRD	Data Review Dashboard

DSM	Data Source Matrix
ECU	Environmental Control Unit
EDVT	Experimentation, Demonstration, and Validation Team
EIO-C	Energy Informed Operations - Central
EIR	Experiment Incident Report
EPA	Environmental Protection Agency
ERDC	Engineer Research and Development Center
FOB	Forward Operating Base
FSC	Field Sanitation Center
GDIT	General Dynamics Information Technology
GIS	Geographical Information System
gpd	gallons per day
HERU	High-Efficiency Refrigeration Unit
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HPT	Hybrid Power Trailer
HVAC	Heating, Ventilation, and Air Conditioning
IECU	Improved Environmental Control Unit
IMS	Integrated Master Schedule
JIFF	Joint Inter-service Field Feeding (Burner)
JP-8	Jet Propulsion fuel, type 8
KCLFF	Kitchen, Company Level, Field Feeding
kW	kilowatt
LINER	Non-woven Composite Insulation Liner
LTT-F	Light Tactical Trailer-Flatdeck
MACK	Modular Appliances for Configurable Kitchens
MANGEN	1kWe JP-8 fueled, Man-Portable Generator Set
MEB	Maneuver Enhancement Brigade
MEP	Mobile Electric Power
MKT	Mobile Kitchen Trailer
MMGT-BOS	Multi-Mode Grid Tie Balance of Systems
MOS	Military Occupational Skill
MP BOLC	Military Police Basic Officer Leader Course
MSAT	Modeling, Simulation, and Analysis Team
MSCoE	Maneuver Support Center of Excellence
MTRCS	Multi-temperature Refrigerated Container System
MySQL	My Structured Query Language
NAS	Network Attached Storage
NCO	Non-Commissioned Officer
NI	National Instrument
NIPRNET	Unclassified but Sensitive Internet Protocol Router Network
NSN	National Stock Number
NSRDEC	Natick Soldier Research, Development and Engineering Center
O&S	Operations & Support
OBVP/TV2GM	Onboard Vehicle Power/Tactical Vehicle-to-Grid Module

OE	Operational Energy
OEPP	Operational Energy Plans and Programs
PAX	Passenger (per JP 1-02; however, for the purposes of this report we use this term to mean “personnel”)
PB	Patrol Base
PCI	Precision Combustion Incorporated
PdM FSS	Product Manager Force Sustainment Systems
PdM PAWS	Product Manager Petroleum & Water Systems
PM E2S2	Program Manager Expeditionary Energy and Sustainment Systems
PMIT	Program Management Integration Team
POR	Programs of Record
PPS	Prime Power School
PSHADE	PowerShade
PV	Photovoltaic
RDEC	Research, Development, and Engineering Center
REDUCE	Renewable Energy for Distributed Under-supplied Command Environments
RIT	Requirements Integration Team
RTD	Resistance Temperature Detector
RWS	Rugged Wireless Scale
SCPL	Single Common Powertrain Lubricant
SEIT	Systems Engineering and Integration Team
SEP	Systems Engineering Plan
SIP-Hut	Structural Insulated Panel - Hut
SITREP	Situation Report
SLB-STO-D	Sustainability and Logistics-Basing Science and Technology Objective - Demonstration
SME	Subject Matter Expert
STO-D	Science and Technology Objective-Demonstration
SV	System View
SQL	Structured Query Language
TARDEC	Tank and Automotive Research, Development and Engineering Center
TC	Thermocouple
TCM	TRADOC Capability Manager
TECD	Technology-Enabled Capability Demonstration
TEMPER	Tent, Extendable, Modular, Personnel
TMIT	Technology Maturation and Integration Team
TOC	Tactical Operations Center or TECD Operations Center
TQG	Tactical Quiet Generator
TRICON	Tri-wall Container
TRL	Technology Readiness Level
UGR-A	Unitized Group Ration – A option
UGR H&S	Unitized Group Ration – Heat & Serve
ULCANS	Ultra-Lightweight Camouflage Net System

UV	Ultraviolet
WATERMON	Real Time Inline Diagnostic Technology for Water Monitoring
WAVE	Wide Area Visualization Environment
WSN	Wireless Sensor Network
WWT	Waste Water Treatment

ANNEX A – INSTRUMENTATION

Appendix A.1 Instrumentation Layout and Mappings

DMMS

Figure A-1 shows the layout of all of the DMMS Boxes that were located at CBITEC. **Table A-1** maps each of the A-mesh DMMS boxes to the boxes’ serial numbers and the technology to which the box was connected. **Table A-2** maps each of the B-mesh DMMS A2D boxes to the technology to which the box was connected.

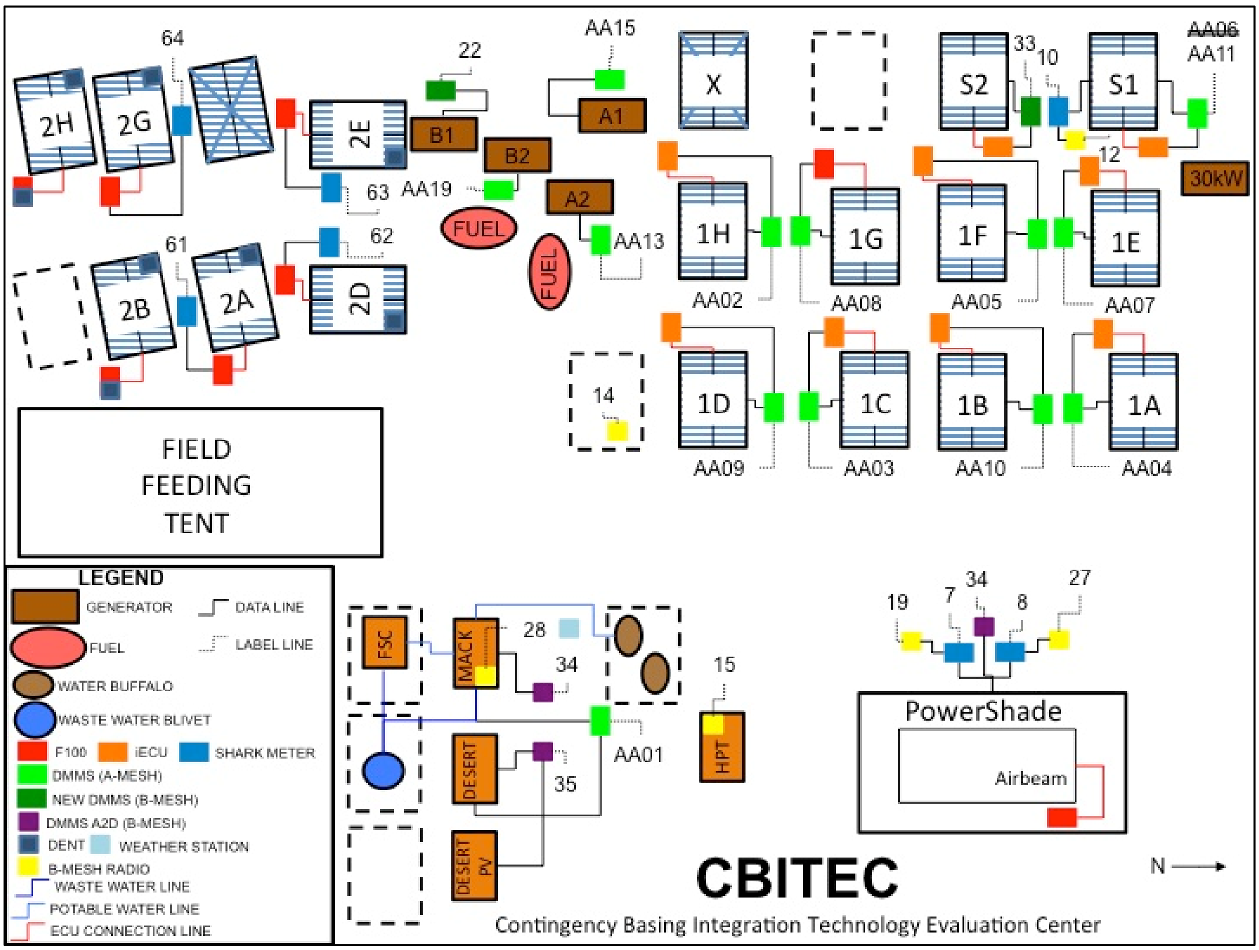


Figure A-1: DMMS Layout

Table A-1: CBITEC A-mesh DMMS Box Mapping

A Mesh Box #	Technology	SN Ending With
AA01	MACK/DESERT	106
AA02	1H	104
AA03	1C	101
AA04	1A	102
AA05	1F	108
AA06	S1	105
AA07	1E	109
AA08	1G	111
AA09	1D	110
AA10	1B	100
AA11	S1	107
AA12	N/A	N/A
AA13	Gen A2	112
AA15	Gen A1	114
AA19	Gen B2	117

Table A-2: CBITEC B-mesh DMMS A2D Box Mapping

B Mesh Radio #	Technology
33	S2
27	PSHADE BOS 2
12	S1 Air Exchanger
19	PSHADE BOS 1
15	HPT
28	MACK (i)
34	MACK (o)
35	DESERT
21	Gen B1

MACK

Figure A-2 shows the instrument layout inside of the MACK. **Table A-3** maps each sensor to the DMMS LabJack connection inside the A2D box and the reading the sensor is taking. **Table A-4** maps each appliance to the PowerScout connected for the voltage and current and the model of the current transformer.

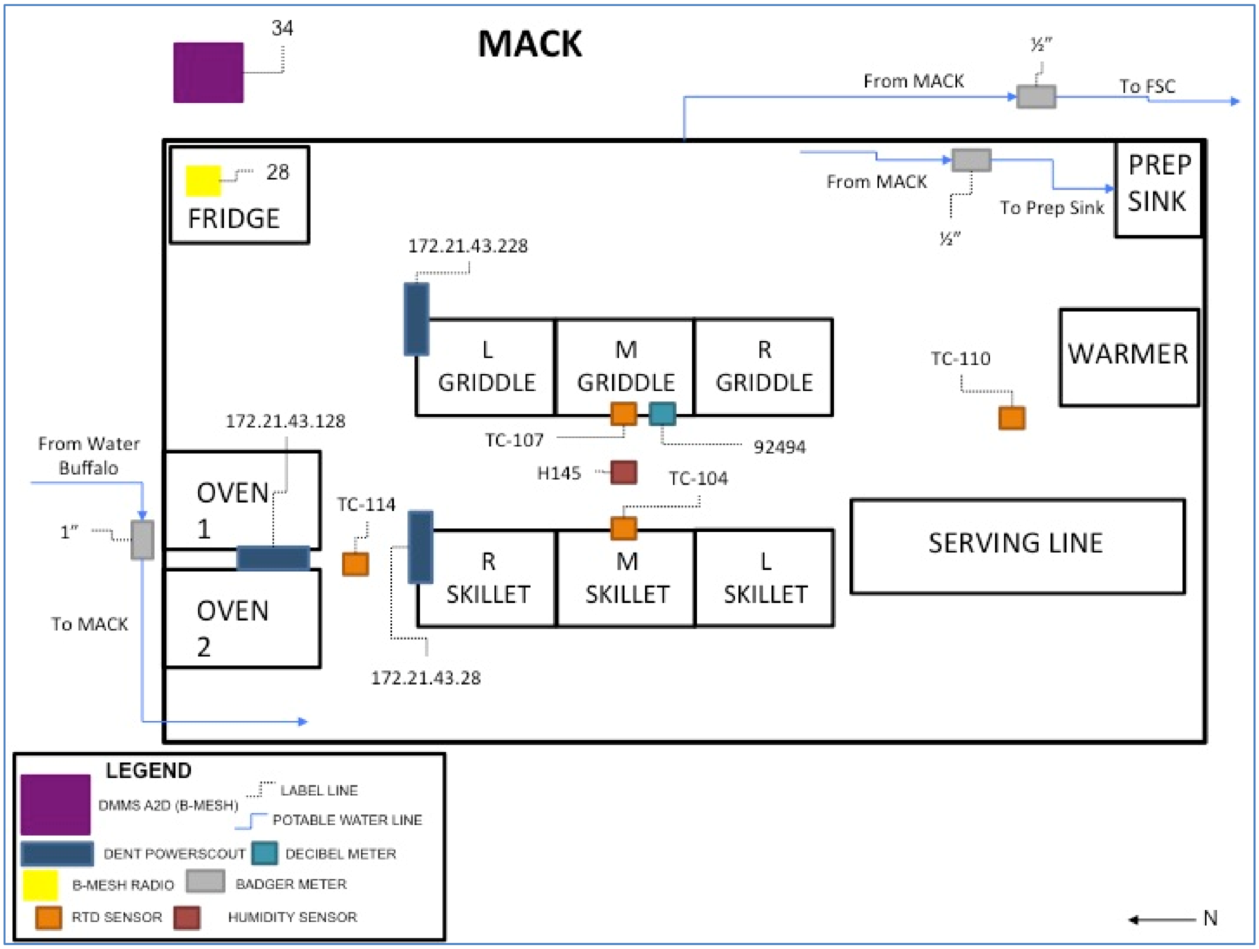


Figure A-2: MACK Layout

Table A-3: MACK DMMS A2D Mapping

Instrumentation	Sensor Type	DMMS LabJack Mapping
Temperature Above Ovens	ProSense TTD25N-20-0300F-H	.34 – A0
Temperature Above Griddles	ProSense TTD25N-20-0300F-H	.34 – A3
Temperature Above Skillets	ProSense TTD25N-20-0300F-H	.34 – A2
Temperature Above Serving Line	ProSense TTD25N-20-0300F-H	.34 – A2
Humidity	HM1500LF	.34 – A4
Total Water Flow	1" Badger meter	.34 – D0
Prep Sink Flow	½" Badger meter	.34 – D1
FSC Flow	½" Badger meter	.34 – D2

Table A-4: MACK DMMS DENT Mapping

Appliance	Current Transformers Type	DMMS DENT PowerScout Current Mapping	DMMS DENT PowerScout Voltage Mapping
Left Oven	150A EZ Clamp	.128 – CT1	.128 – L1
Right Oven	150A EZ Clamp	.128 – CT2	.128 – L2
Serving Line	150A EZ Clamp	.128 – CT3	.128 – L3
Left Skillet	150A EZ Clamp	.28 – CT3	.28 – L3
Middle Skillet	150A EZ Clamp	.28 – CT2	.28 – L2
Right Skillet	150A EZ Clamp	.28 – CT1	.28 – L1
Left Griddle	20A Split Core	.228 – CT1	.228 – L1
Middle Griddle	20A Split Core	.228 – CT2	.228 – L2
Right Griddle	20A Split Core	.228 – CT3	.228 – L3

DESERT

Figure A-3 shows the instrument layout inside the DESERT. **Table A-5** maps each sensor to the DMMS LabJack connection inside the A2D box and the reading the sensor is taking.

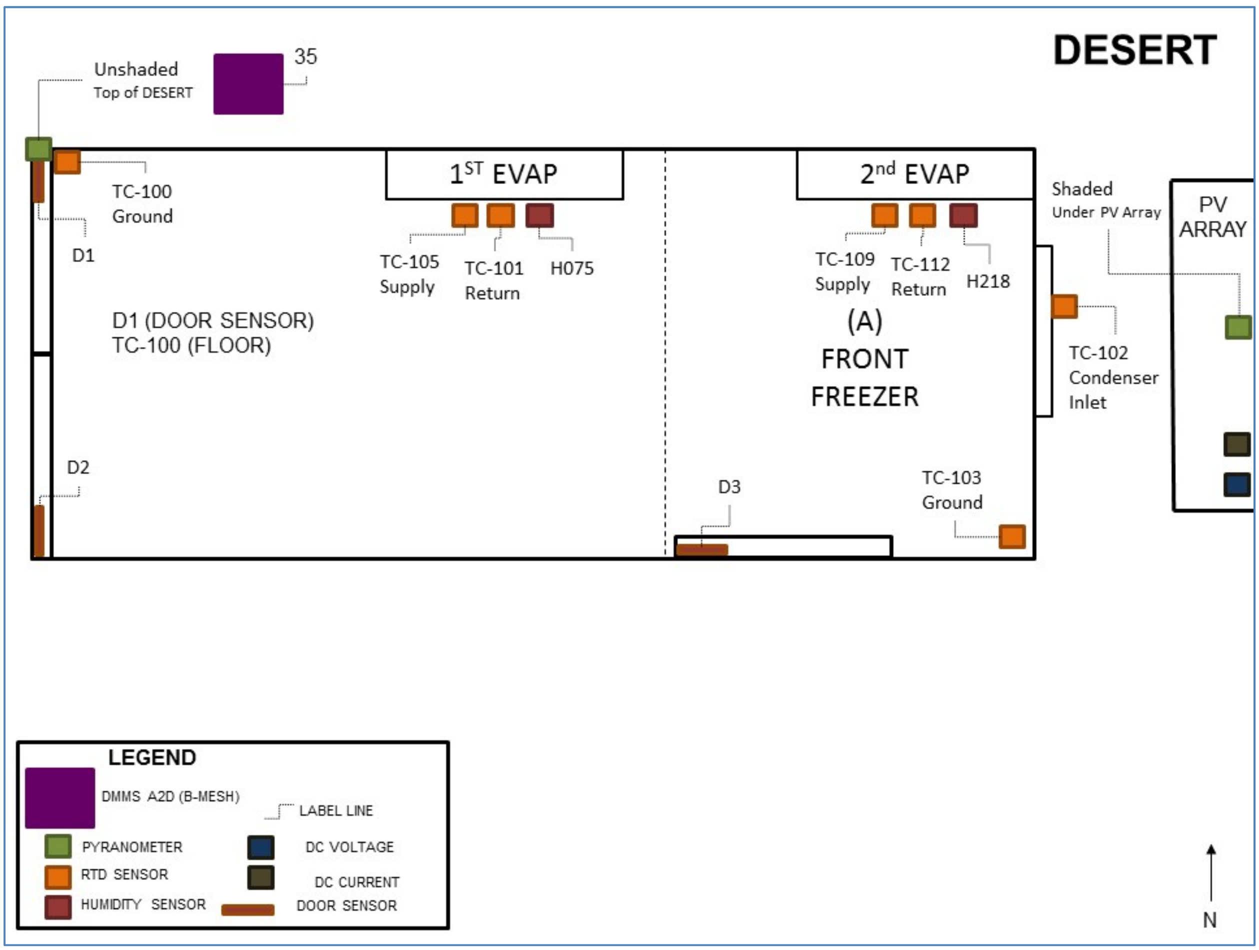


Figure A-3: DESERT Layout

Table A-5: DESERT DMMS A2D Mapping

Instrumentation	Sensor Type	DMMS LabJack Mapping
Left Rear Door Sensor	SM-205Q	.35 – D0
Right Rear Door Sensor	SM-205Q	.35 – D1
Side Door Sensor	SM-205Q	.35 – D2
Humidity Front Compartment	HM1500LF	.135 – A2
Humidity Rear Compartment	HM1500LF	.135 – A3
Temperature 1st Evaporator Return	ProSense TTD25N-20-0300F-H	.35 – A4
Temperature 1st Evaporator Supply	ProSense TTD25N-20-0300F-H	.35 – A3
Temperature 2nd Evaporator Return	ProSense TTD25N-20-0300F-H	.35 – A2
Temperature 2nd Evaporator Supply	ProSense TTD25N-20-0300F-H	.35 – A1
Temperature Bottom Right Rear	ProSense TTD25N-20-0300F-H	.35 – A0
Temperature Bottom Left Front	ProSense TTD25N-20-0300F-H	.35 – A6
Temperature Condenser Input	ProSense TTD25N-20-0300F-H	.35 – A5
Unshaded Pyranometer	SP-214	.135 – A1
Shaded Pyranometer	SP-214	.135 – A0
PV DC Voltage	DVT-1000-V05	.135 – A5
PV DC Current	DCT100-42-24-S	.135 – A4

WWT-Bio

Figure A-4 shows the instrument layout inside the WWT-Bio.

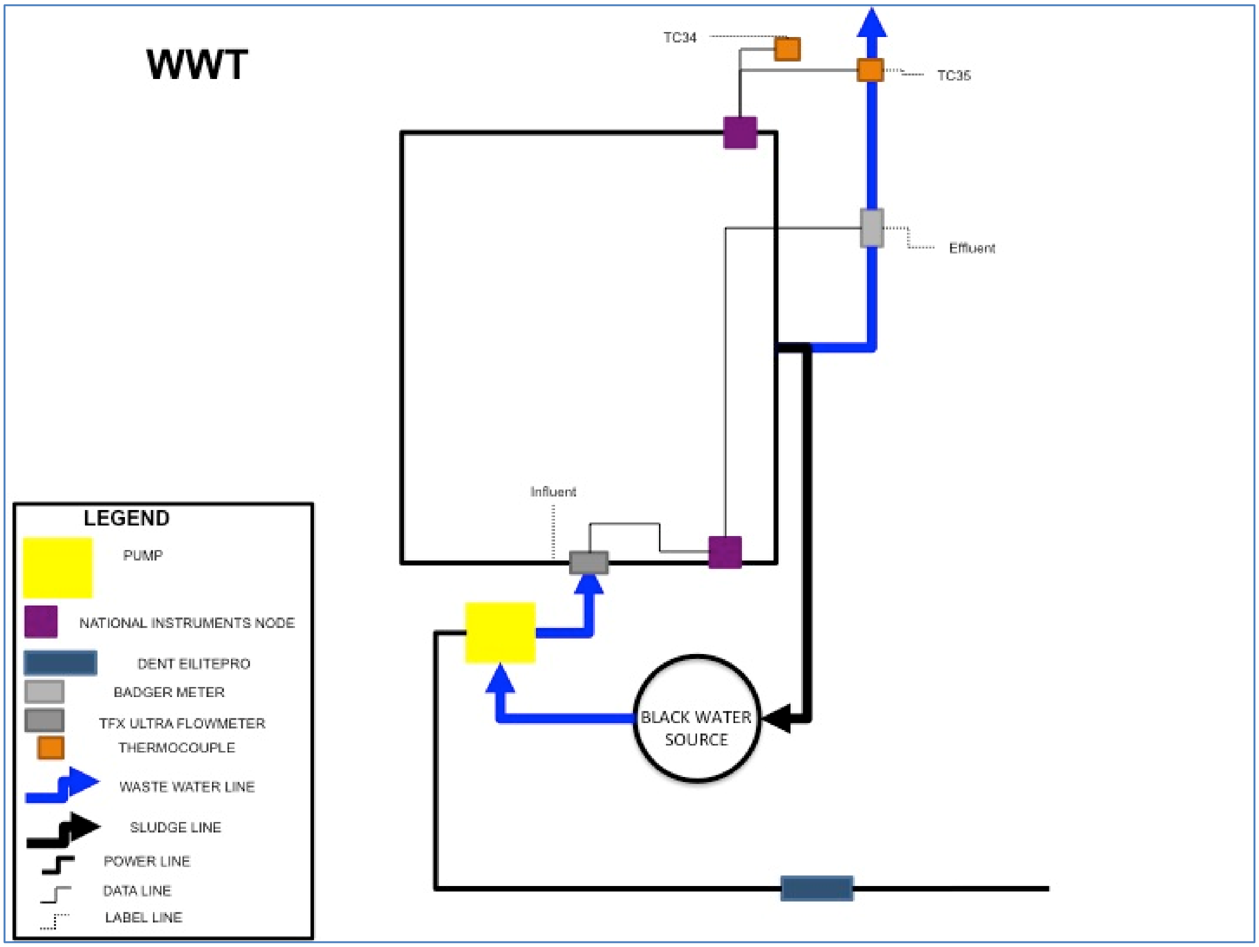


Figure A-4: WWT-Bio Layout

PSHADE

Figure A-5 shows the instrument layout inside of the PSHADE. **Table A-6** maps each sensor to the DMMS LabJack connection inside the A2D box and the reading the sensor is taking.

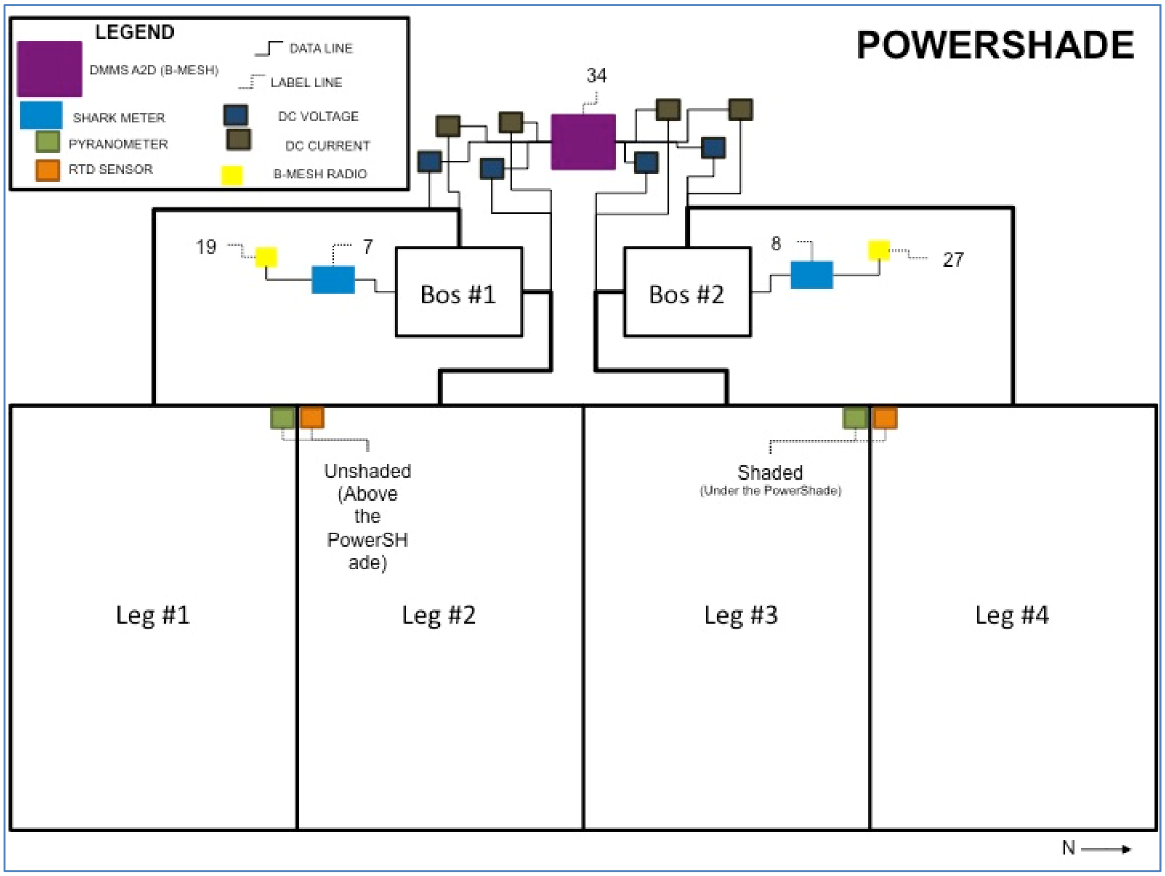


Figure A-5: PSHADE Layout

Table A-6: PSHADE DMMS Mapping

Instrumentation	Sensor Type	DMMS LabJack Mapping
Unshaded Pyranometer	Apogee Model SP-214	.22 – A0
Shaded Pyranometer	Apogee Model SP-214	.22 – A1
Temperature Unshaded	ProSense TTD25N-20-0300F-H	.22 – A3
Temperature Shaded	ProSense TTD25N-20-0300F-H	.22 – A2
PV DC Voltage Leg #1	DVT-1000-V05	.22 – A4
PV DC Current Leg #1	DCT100-42-24-S	.122 – A0
PV DC Voltage Leg #2	DVT-1000-V05	.22 – A5
PV DC Current Leg #2	DCT100-42-24-S	.122 – A1
PV DC Voltage Leg #3	DVT-1000-V05	.22 – A6
PV DC Current Leg #3	DCT100-42-24-S	.122 – A2
PV DC Voltage Leg #4	DVT-1000-V05	.22 – A7
PV DC Current Leg #4	DCT100-42-24-S	.122 – A3

SIP-Huts

Figure A-6 shows the instrument layout inside the SIP-Huts. **Table A-7** maps each sensor to the DMMS LabJack connection inside the A2D box and the reading the sensor is taking.

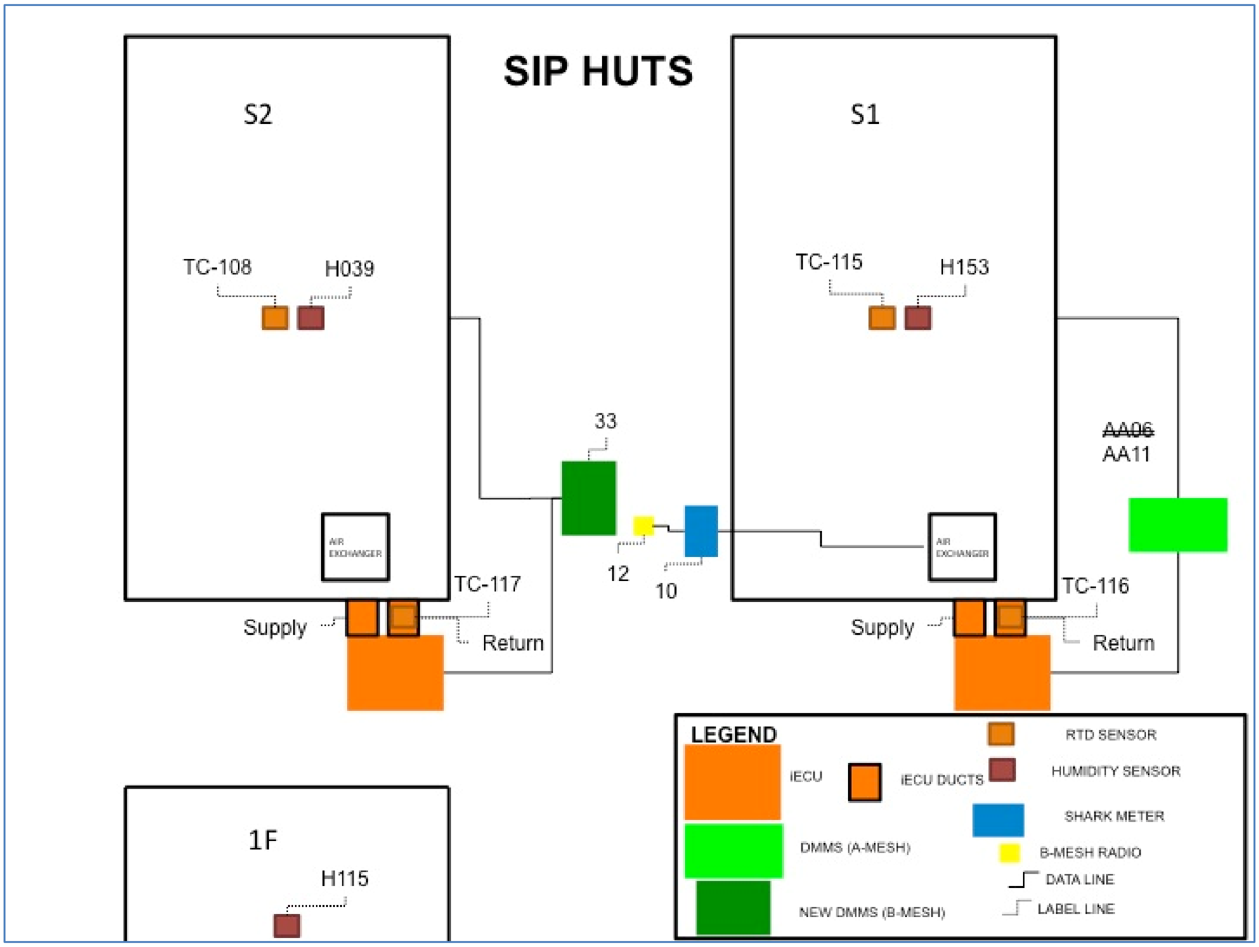


Figure A-6: SIP-Huts Layout

Table A-7: SIP-Hut DMMS Mapping

Instrumentation	Sensor Type	DMMS LabJack Mapping
S1 Humidity	HM1500LF	.33 – A5
S1 Internal Temperature	ProSense TTD25N-20-0300F-H	.33 – A2
S1 Return Duct Temperature	ProSense TTD25N-20-0300F-H	.33 – A1
S2 Humidity	HM1500LF	.33 – A7
S2 Internal Temperature	ProSense TTD25N-20-0300F-H	.33 – A4
S2 Return Duct Temperature	ProSense TTD25N-20-0300F-H	.33 – A3
1F Humidity	HM1500LF	.33 – A6

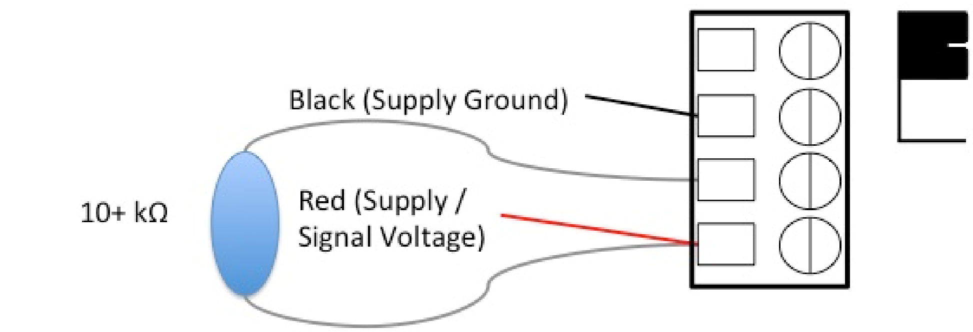
Appendix A.2 Wiring Diagrams

Figure A-7 shows how to wire the Badger flow meters into the DMMS A2D box. The black supply ground wire for the Badger flow meter is connected into the 3rd input of the digital LabJack connection. The red supply and signal voltage wire for the Badger flow meter is connected into the 1st input of the digital LabJack connection. A resistor of at least 10 kΩ is connected between the 1st and 2nd inputs of the digital LabJack connection. A jumper is placed between the 2nd and 3rd pins to complete the installation of the flow meter.

FLOW METER

Badger 250BR05 & 250BR15

LabJack Digital



Model	K Value	Offset	Pulses per Gallon
250BR05	0.337379	0.097041	195.0994
250BR10	0.397368	0.261768	190.5188

$$Pulses\ per\ Gallon = \frac{60 + 60 * Offset}{K\ Value}$$

Figure A-7: Flow Meter Wiring Diagram

Figure A-8 shows how to wire the door sensor into the DMMS A2D box. The black supply voltage wire for the SecoLarm door sensor is connected into the 1st input of the digital LabJack connection. The red supply ground wire for the door sensor is connected into the 3rd input of the digital LabJack connection. No jumper is need to complete the installation of the door sensor.

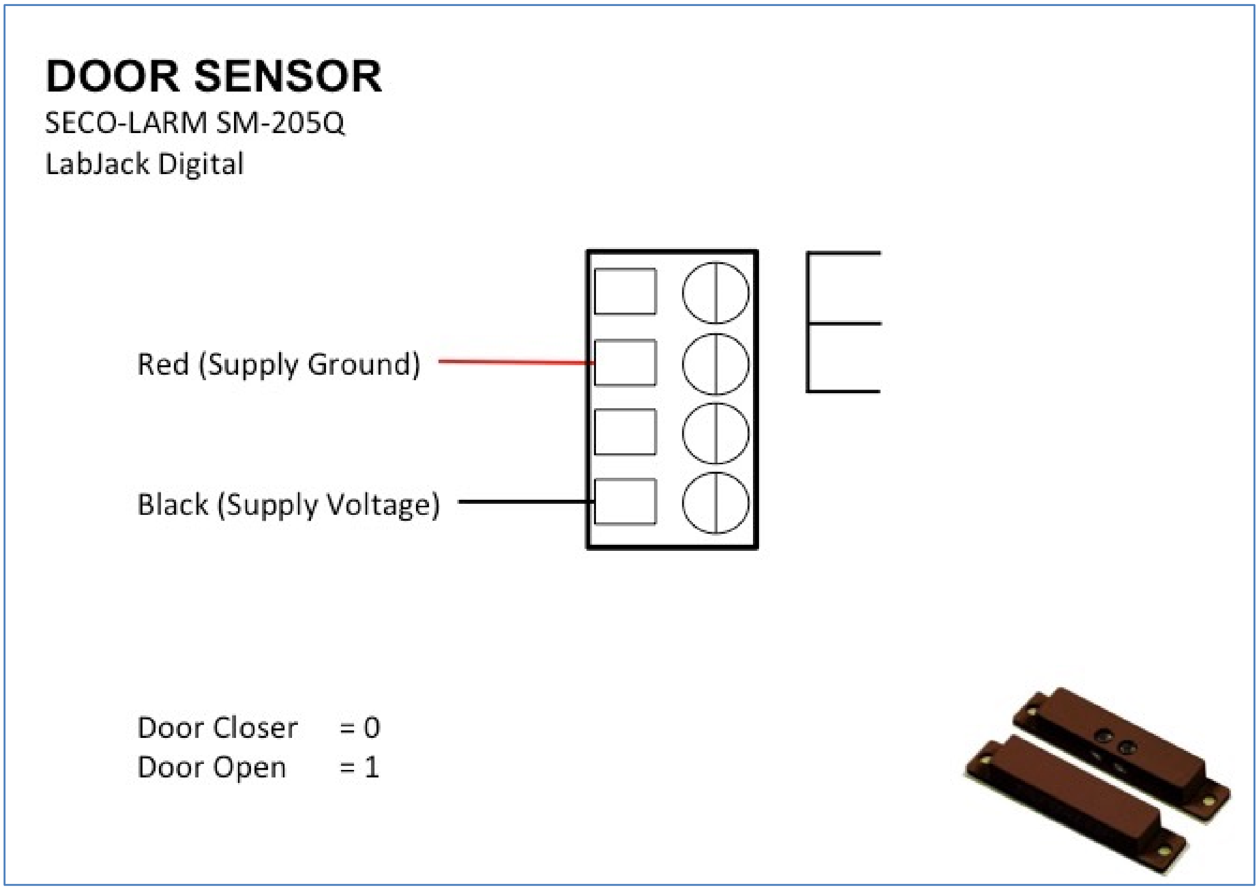


Figure A-8: Door Sensor Wiring Diagram

Figure A-9 shows how to wire the pyranometer into the DMMS A2D box. The white signal voltage wire for the pyranometer is connected into the 1st input of the analog LabJack connection. The red supply voltage wire for the pyranometer is connected into the 2nd input of the analog LabJack connection. The black supply ground wire for the pyranometer is connected into the 3rd input of the analog LabJack connection. The green signal ground and clear shield ground wires for the pyranometer is connected into the 4th input of the analog LabJack connection. Jumpers are placed on the 3rd and 4th pin sets and between the 1st and 2nd pins of the 1st pin set to complete the installation of the pyranometer.

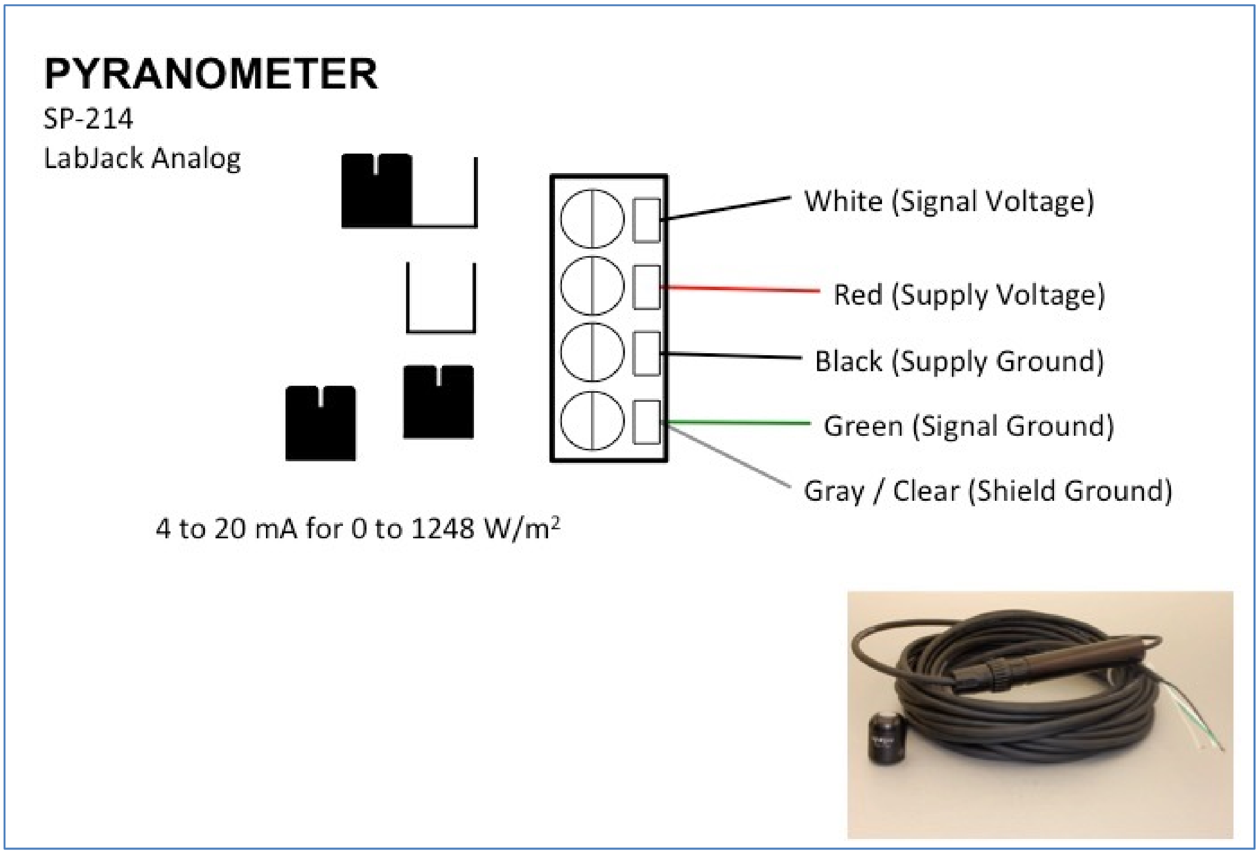


Figure A-9: Pyranometer Wiring Diagram

Figure A-10 shows how to wire the humidity sensor into the DMMS A2D box. The yellow signal voltage wire for the humidity sensor is connected into the 1st input of the analog LabJack connection. The blue supply voltage wire for the humidity sensor is connected into the 2nd input of the analog LabJack connection. The white supply ground wire for the humidity sensor is connected into the 3rd input of the analog LabJack connection. Jumpers are placed on the 2nd pin set and between the 2nd and the 3rd pins of the 1st pin set to complete the installation of the humidity sensor.

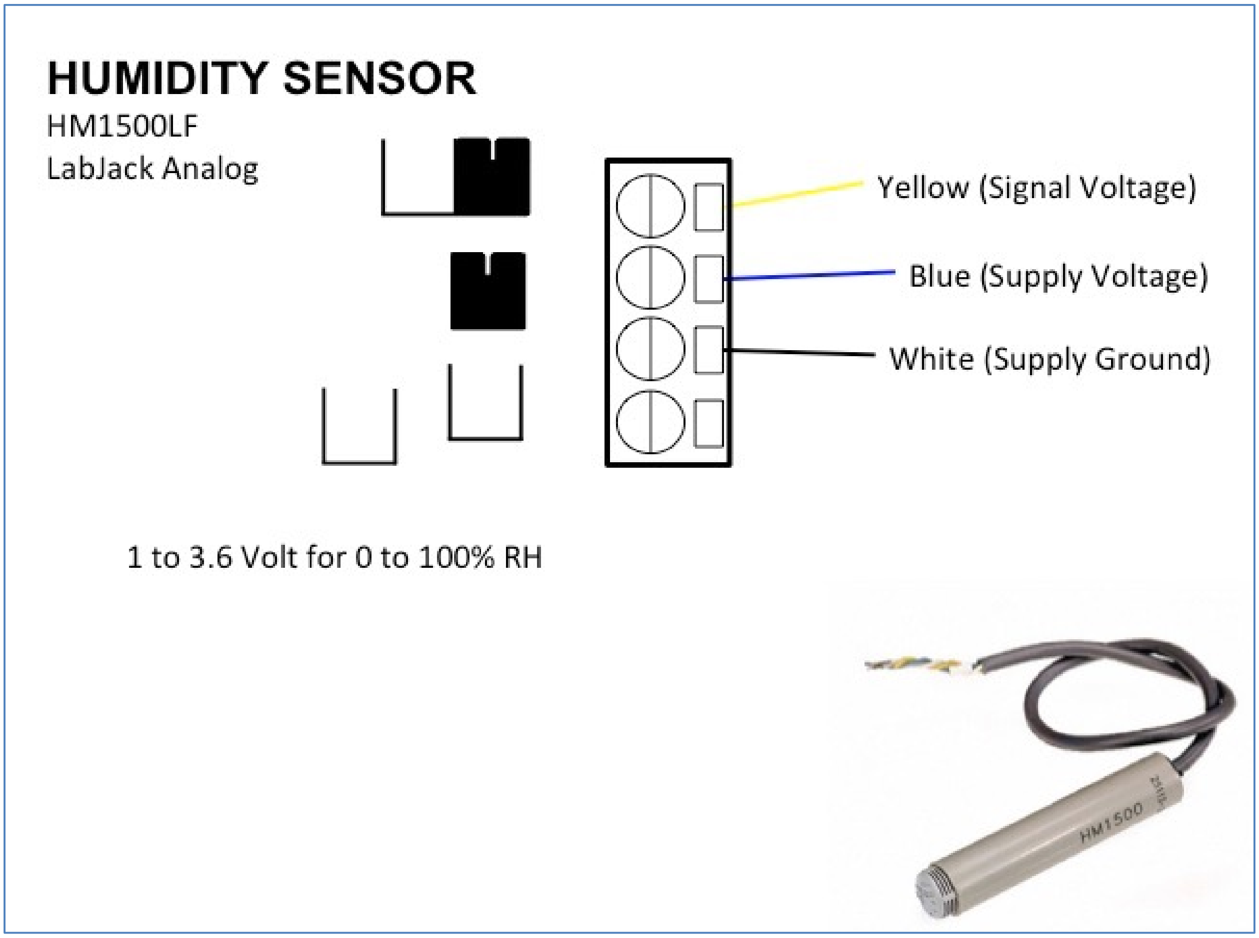


Figure A-10: Humidity Wiring Diagram

Figure A-11 shows how to wire the Resistance Temperature Detector (RTD) into the DMMS A2D box. The white signal voltage wire for the RTD is connected into the 1st input of the analog LabJack connection. The brown supply voltage wire for the RTD is connected into the 2nd input of the analog LabJack connection. Jumpers are placed on the 1st pin set and between the 1st and 2nd pins of the 1st pin set to complete the installation of the RTD.

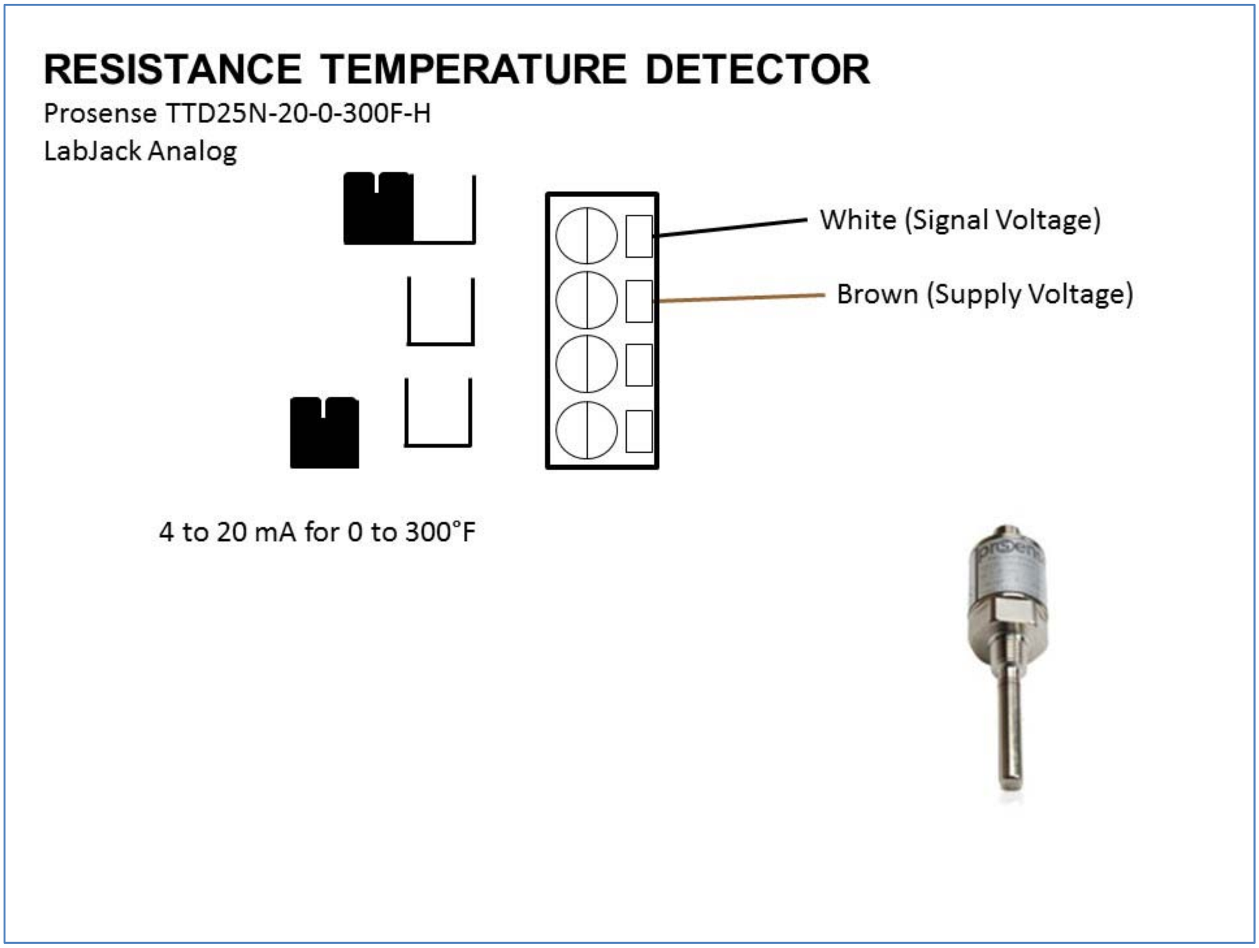


Figure A-11: Resistance Temperature Detector Wiring Diagram

Figure A-12 shows how to wire the DC current transducer into the DMMS A2D box. The signal voltage wire for the DC current transducer is connected into the 1st input of the analog LabJack connection. The supply voltage wire for the DC current transducer is connected into the 2nd input of the analog LabJack connection. The supply ground wire for the DC current transducer is connected into the 3rd input of the analog LabJack connection. The signal ground wire for the DC current transducer is connected into the 4th input of the analog LabJack connection. Jumpers are placed on the 3rd and 4th pin sets and between the 1st and 2nd pins of the 1st pin set to complete the installation of the DC current transducer.

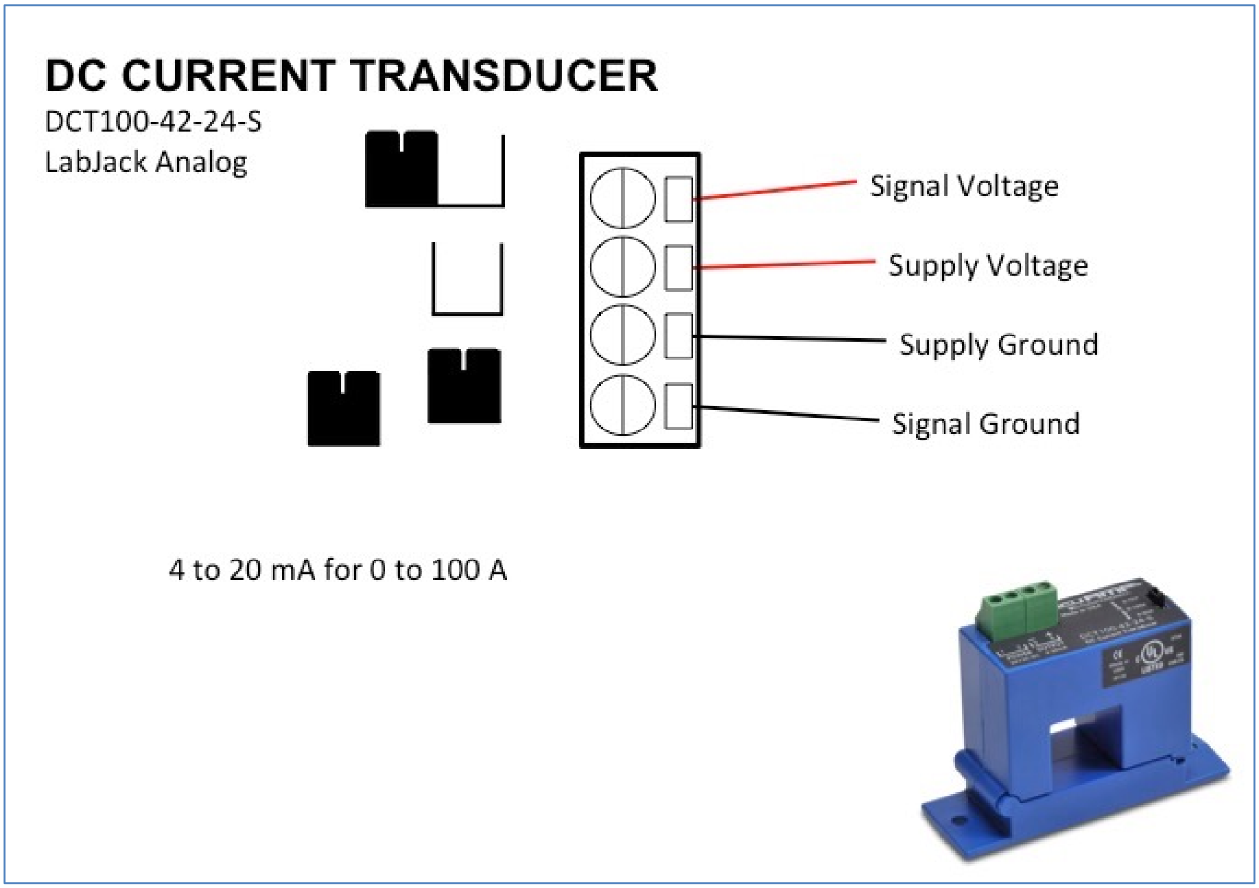


Figure A-12: DC Current Transducer Wiring Diagram

Figure A-13 shows how to wire the DC voltage transducer into the DMMS A2D box. The signal voltage wire for the DC voltage transducer is connected into the 1st input of the analog LabJack connection. The supply voltage wire for the DC voltage transducer is connected into the 2nd input of the analog LabJack connection. The supply ground wire for the DC voltage transducer is connected into the 3rd input of the analog LabJack connection. Jumpers are placed on the 3rd and 4th pin sets and between the 1st and 2nd pins of the 1st pin set to complete the installation of the DC voltage transducer.

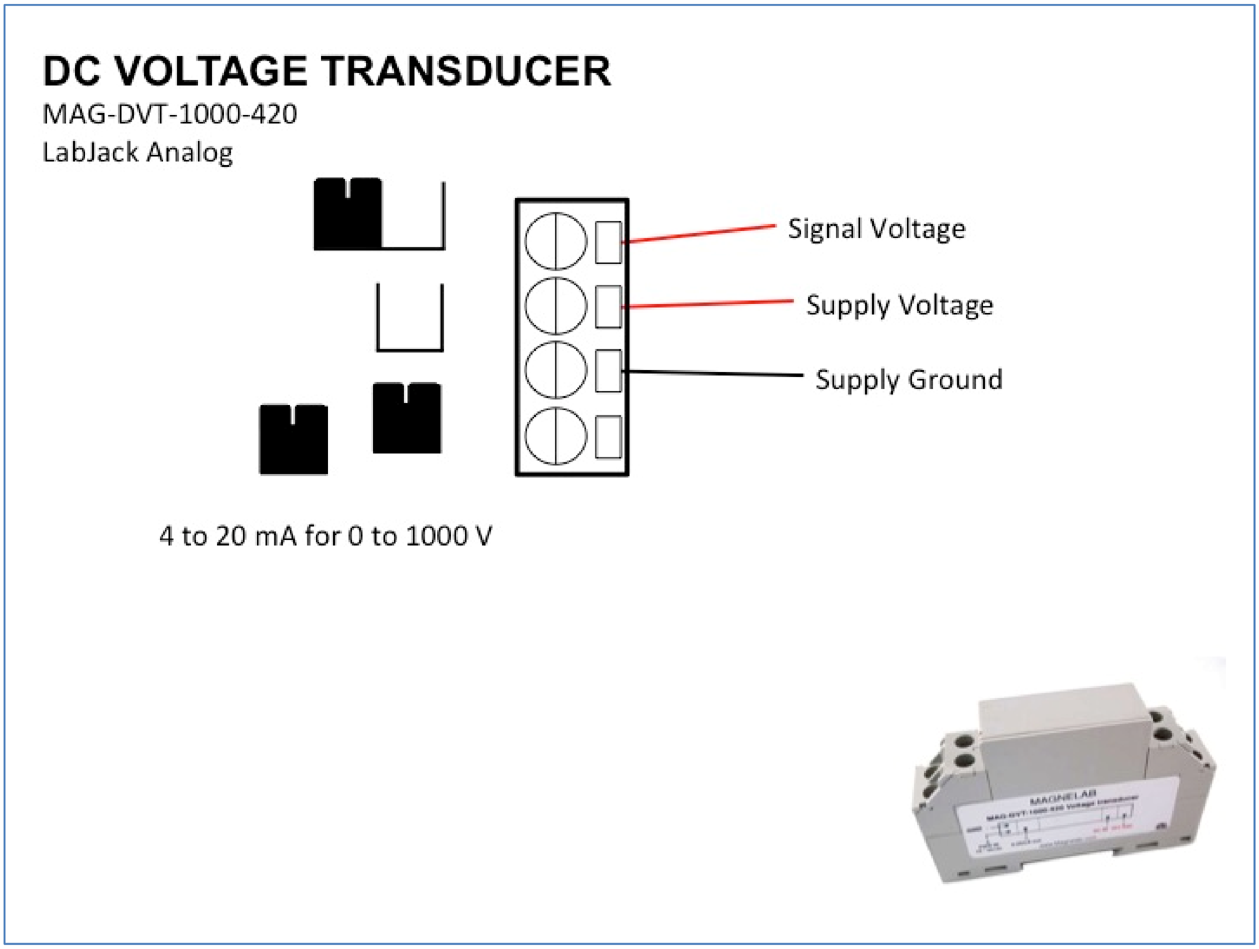


Figure A-13: DC Voltage Transducer Wiring Diagram

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ANNEX B – SIP-HUT/B-HUT/EIO-C SOUND TEST
Procedures and Results

Testers: Colleen Ottomano, Joseph Quigley, Janet Langley

Date: Friday April 24, 2015

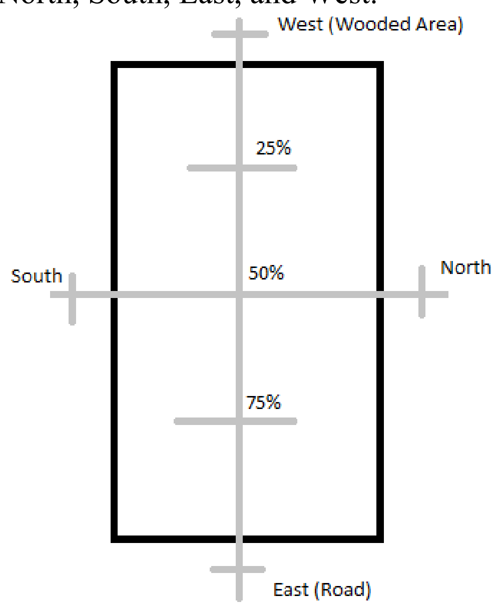
Objective of experiment: Quantify the acoustic properties of the SIP-Hut and B-Huts.

Equipment involved:

- SIP-Hut #2 (no solar shade) and IECU
- B-Hut 1F (Radiant Liner) and IECU
- B-Hut 1H (Silver Paint) and IECU
- EIO-C two 60kW generators (both running during sound measurements)
- 30kW generator (running during sound measurements)

Procedure:

Two Omega sound meters with data logging SD cards, model number HSL402SD, decal numbers 92495 and 92494, were used. For exterior sound readings the meter was directed towards the hut. Interior sound measurements were taken with the meter facing south. Sound readings were taken at seven locations in and around each hut, three inside the hut at 25, 50, and 75% of the hut length along the midline. Four exterior locations offset 10 ft from each wall, labeled in the graphic below North, South, East, and West.



The interior conditions of each hut was documented via photographs. Interior and exterior sound measurements were taken with the ECUs on and off. SIP-Hut interior sound measurements were taken with the air exchanger ON and OFF.

Data Recorded:

Figure B-1: Exterior of SIP-Hut 2, East Wall

Figure B-2: Interior of SIP-Hut 2, Bunks Installed in Hut, ECU Ducts, Air Exchanger and Air Exchanger Ducts

Table B-1:

SIP-Hut#2, IECU, No Solar Shade			
ECU on, Air Exchanger On			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	67.6	NA	NA
50%	67.4	NA	NA
75%	68.1	NA	NA
North	65.8	10ft	62ft 10in to 30KW generator 18ft 6in to SIP-HUT #1
East	68	10ft	22ft to B-HUT 1F
South	64.5	10ft	53ft 3in to X-Hut
West	61	10ft	Woods NA (distance approximated ~150ft)

Table B-2:

SIP-Hut#2, IECU, No Solar Shade			
ECU Off, Air Exchanger On			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	58.5	NA	NA
50%	58.3	NA	NA
75%	58.3	NA	NA
North	64.7	10ft	62ft 10in to 30KW generator 18ft 6in to SIP-HUT #1
East	67	10ft	22ft to B-HUT 1F
South	62	10ft	53ft 3in to X-Hut
West	61	10ft	Woods NA (distance approximated ~150ft)

Table B-3:

SIP-Hut#2, IECU, No Solar Shade			
ECU Off, Air Exchanger Off			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	54.1	NA	NA
50%	51.1	NA	NA
75%	52.5	NA	NA
North	64.7	10ft	62ft 10in to 30KW generator 18ft 6in to SIP-HUT #1
East	67	10ft	22ft to B-HUT 1F
South	62	10ft	53ft 3in to X-Hut
West	61	10ft	Woods NA (distance approximated ~150ft)

Figure B-3: Exterior of B-Hut 1F, East Wall

Figure B-4: Exterior of B-Hut 1F, West Wall and ECU.

Table B-4:

B-Hut#1F, IECU, No Solar Shade, with Radiant Liner			
ECU On			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	68.4	NA	NA
50%	68.4	NA	NA
75%	71.1	NA	NA
North	64.2	10ft	19ft 2in to B-Hut
East	67.5	10ft	21ft 4in to B-Hut
South	63.5	10ft	19ft 2in to B-Hut
West	70	10ft	22ft to B-HUT 1F

Table B-5:

B-Hut#1F, IECU, No Solar Shade, with Radiant Liner			
ECU Off			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	56.3	NA	NA
50%	53.4	NA	NA
75%	54	NA	NA
North	63.7	10ft	19ft 2in to B-Hut
East	68	10ft	21ft 4in to B-Hut
South	63	10ft	19ft 2in to B-Hut
West	68	10ft	22ft to B-HUT 1F

Figure B-5: Exterior of B-Hut 1H, East Wall

Figure B-6: Interior of B-Hut 1H, Bunks Installed, Ducts Installed and ECU

Table B-6:

B-Hut#1H, IECU, No Solar Shade, With Silver Paint			
ECU On			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	70.7	NA	NA
50%	66.7	NA	NA
75%	71	NA	NA
North	78	10ft	19ft 2in to B-Hut
East	72.4	10ft	21ft 4in to B-Hut
South	76.5	10ft	21ft 9in to EIO-C Generator 4
West	74	10ft	To X-Hut: to vestibule 16ft in 4in, main structure21ft 4in

Table B-7:

B-Hut#1H, IECU, No Solar Shade, With Silver Paint			
ECU Off			
Location	dB	Stand off	Distance between wall and nearest reflective item
25%	60	NA	NA
50%	61	NA	NA
75%	61	NA	NA
North	68	10ft	19ft 2in to B-Hut
East	73	10ft	21ft 4in to B-Hut
South	77	10ft	21ft 9in to EIO-C Generator 4
West	72.6	10ft	To X-Hut: to vestibule 16ft in 4in, main structure21ft 4in

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ANNEX C – PRIME POWER SCHOOL VISIT AND TRAINING

(Reprint of original)

SUBJECT: Prime Power School (PPS) visit to the SLB-STO-D 1000-person Base Camp Demonstration

LOCATION: CBITEC

WHEN: 13 April 2015, 0900-1030 hours

0855 hours, Introduction (in the DOC):

Scott Werkmeister welcomed the twelve students and one instructor to the demo (rank ranged from E-5 to E-7), then gave them an overview of our schedule for the morning. There were 7 SSGs and 6 SGTs.

Tom Decker briefed the Soldiers on the CBITEC venue.

Bill Harris introduced the SLB-STO-D and fuel/water/waste challenge.

Then the Soldiers rotated through EIO-C, DMMS, HPT, and PSHADE.

0900 hours, EIO-C:

The Soldiers moved outside to the EIO-C area. Stefan Siegfried gave an overview of the EIO-C project.

Jaclyn Lynch briefed the IPD as a piece of equipment much like a modified PDISE M200. The Soldiers asked a number of questions.

Q: Diesel gensets are most efficient at operating temperature. Can your "box" help keep gensets at operating temperature?
A: No, the system does not take that into account at this time.

Q: How many gensets can you integrate?
A: Goal is five to six.

Q: How Soldier friendly is it? Will it be operated/maintained by a Soldier or a contractor? (comment: "We don't see this set up at generator school.")
A: (The team did not have the information to answer this question directly. The program has not yet reached the point for this decision to be made.)

Q: How scalable is this system?
A. 200A, up to 300kW.

Soldier commented that gensets are only 30% fuel efficient. Said this was the reason for his scalability question. Bill mentioned that the scope of this effort is for small and very small contingency base camps, not an installation.

Soldiers went back in the DOC and Jeff Grossmann briefed them on the EIO-C app. The application can be run on a phone, tablet, or PC. Can monitor the IPDs, gensets, and loads, both smart loads and dumb loads. The grid can operate without the app. When you start the app it maps the grid. Can track power and fuel. Jeff explained the operation of the grid in response to the load. Can see this on the graph in the app.

Q: Can the dashboard just monitor, or can it also remotely control the system?
A: It can do both, monitor and remotely control the gensets and IPDs, e.g., can use the app to start and stop generators.

Q: How fast could another genset come online?
A: The TQG has some start-up time, but maybe 10-15 sec.

This question lead to a short mention of whether or not you want to have a running reserve. Seems for an immediate response time a running reserve would be a trade-off with saving fuel. Different modes could be established, e.g. maintenance (run time), fuel savings, etc.

Tom mentioned that Cummins is working with EIO-C for battery storage as part of future grid. Give the commander a silent mode when a potential threat is detected "outside the wire."

Q: How does it select which generator comes on line?
A: Jeff indicated that the largest generator on the grid will come on line first. This question led to some discussion on staggering genset usage for maintenance timing and fuel levels.

(Why? Shouldn't it best fit the load required?)

Q: How often do you have to conduct maintenance on the IPD?
A: We are not sure yet. This will be determined during the acquisition life cycle of the equipment during testing.

We will also need to determine test equipment required and training required.

Q: Can you disable a generator on the grid?
A: Yes, if the e-stop is engaged.

Q: What happens if I lose an IPD? How does the genset react?
A: If the electronics fail the IPD works like a PDISE M200.

Q: Does the IPD have a fault alarm and is continuous monitoring required to detect the fault? (2)

A: The application reports a loss of communication but it still requires a Soldier to monitor the app.

Q: What is the range of the wireless communications; can it be jammed?
A: Tom mentioned that he is working with EIO-C on a wireless monitoring and control communication mechanism. Right now the systems are connected to the app with an Ethernet cable.

Q: How many IPDs can you monitor?
A: The app can monitor several grids, each grid with 5-6 IPDs.

Jeff showed that the app has extracts from the Technical Manuals available.

Q: Have you done circuit analysis?
A: Yes. We have exercised some destructive testing to see how the system reacts to overloads.

Q: Has any environmental testing been done on the system?
A: PMs are aware of the applicable mil standards required for this equipment and will ensure compliance during the acquisition process.

Q: Are the EIO-C gensets unique to their system?
A: Gensets are standard TQGs with retrofit communications modules installed.

Then the Soldiers moved back outside the DOC and we took them inside the fence to see the control box on the modified TQG. (The commander signed the risk assessment to allow the Soldiers access to the equipment.)

0945, DMMS

Tom briefed the Soldiers on the DMMS boxes inside the EIO-C fence. He compared the original Pelican box DMMS to the new, smaller, more compact DMMS box. He mentioned that units often rely on generator mechanics for help with power distribution, but mechanics are not trained on this. The DMMS is a tool that units can use to help with this.

Tom showed the Soldiers a box outside one of the B-huts in the north block. He pointed out where the power enters the box, where it exits the box, and where the data is routed out the box to an antenna. Wireless is preferred because wires can be cut or broken. He uses DIACAP-approved wireless radios that don't interfere with other camp wireless capabilities. Through wireless we can only monitor the grid, we cannot control the grid.

Q: Can the wireless be jammed? (9)
A: Of course, as can all signals.

Tom mentioned that 58% of our power on the battlefield is for ECUs. Using the DMMS can help make this more efficient.

Tom led the Soldiers up to the Admin Building. Enroute he mentioned the large PV array. This will be part of the PPS POI in the future.

Showed the Soldiers the CB-EMS dashboard. Noted that while the technologies, like those from the SLB-STO-D may come for evaluation then leave, the DMMS is part of the permanent camp infrastructure. Tom pointed out the large rack of electronic components required for IA compliance. DOE developed the dashboard to control a nuclear power plant. So it could be used to control the grid, but we don't have the authority to do that. Tom talked about connecting to WAVE so that you could see the dashboard from your desk.

Q: What is the maximum number of boxes that can be monitored? (11)
A: DOE designed it to read 65,000 sensors every half second. We have about 20.

1010, HPT

Tom led the Soldiers over to the HPT. He mentioned that the TQG could be disconnected from the large batteries and used for spot generation if required. The lithium ion batteries have 80kWh capacity. The system is 480Vdc. Anything over 50 is considered high voltage and specialized PPE and training is required. The system is designed to be Soldier-friendly. 30kW inverter gives a peak of 30kW. Get reduced noise by running off battery.

1020, PSHADE

Tom led the Soldiers over to the PSHADE. Pointed out the MMGT BOS pelican boxes. Mentioned there are eight HMMWV batteries storing energy. Mentioned the Air Force is also interested in systems like this for their "base camp in a box."

Conclusion

Reminded the Soldiers that we will meet with them on Wednesday. We asked them to think of more questions and concerns. Suggested they think of implications like training requirements, set up time, etc.

ANNEX D – FOCUS GROUP REPORTS

This annex consists of the two printed reports as Appendices D.1 and D.2. These are reprints of the originals.

Appendix D.1 Prime Power School Report

1 Introduction

The Sustainment Logistics Basing Science and Technology – Demonstration (SLB-STO-D) conducted a focus group discussion on four electrical power candidate technologies included as part of a 1000-person camp demonstration. This demonstration was conducted at the Contingency Basing Integration Technology Evaluation Center (CBITEC) at Fort Leonard Wood, MO during the period 6-25 April 2015. The electrical power technologies that were discussed were the Hybrid Power Trailer (HPT), Energy Informed Operations – Central (EIO-C), PowerShade (PSHADE), and Deployable Metering and Monitoring System (DMMS). The goal of this focus group discussion was to collect qualitative feedback from students and cadre of the U.S Prime Power School, who would ultimately be a primary users and/or trainers of these technologies, if fielded. Thirteen Soldiers (rank ranged from E-5 to E-7) from the Prime Power School participated in the focus group session that was conducted on 15 April 2015 at Fort Leonard Wood, MO.

2 Methods & Participants

Soldiers met with the SLB-STO-D Lead Systems Engineer, various members of NSRDEC and other members of the U.S. Army Corps of Engineers to discuss the aforementioned four candidate technologies.

A general outline was followed, which listed topics to be discussed during the focus group such as best uses of the system, maintainability, supportability, and recommendations for improvement. Soldiers were asked to provide candid feedback to help improve the acceptability of the systems. Notes were taken by various attendees and are summarized in this report.

3 Results

3.1 Hybrid Power Trailer (HPT)

The Soldiers provided candid feedback on the HPT during the focus group session. Their comments related to employment of the system, supportability, maintainability, and potential improvements. Their input was captured and is presented in the sections below.

3.1.1 Employment of HPT

Concerning the best use of the HPT, the Soldiers indicated the following:

- Due to reliability/redundancy, the HPT would best be employed for critical facilities on small bases.

- Due to HPT's mobility, it is best suited to be placed in remote areas for temporary power until shore power is established.

3.1.2 Supportability of HPT

The Soldiers' comments regarding supportability were:

- Generator technician could maintain but additional training is needed for the batteries. May need contractor support.
- Not enough prime power personnel to dedicate them to the system. They could be called upon to troubleshoot, but anything above basic service would require additional support.

3.1.3 Maintainability of HPT

The Soldiers commented on maintainability issues as follows:

- If the HPT breaks in the field, it is best not to separate generator and batteries since they would all be considered part of a system. If the system is classified as a single end item, do not see the generator being separated from the battery bank for services.
- Separating the generator and batteries and making them separate end items may facilitate property tracking and maintenance.

3.1.4 Potential Improvements to HPT

The Soldiers provided the following recommendations for improvements:

- Increase size beyond current range (0-30 kW).
- Research more stable and safe battery chemistries. This comment relates to discussions on LiPo vs. Li-ion batteries.
- Improve current capacity of 2 kW for 8 hours on battery power.
- Efficiency vs back-up power is back-up power generation more important than stored battery power? Would like to better understand "why". Fuel savings? Backup redundancy?
- Can the excess power of existing base camp supply be used to charge the batteries instead of having a dedicated genset on the system?
- Could the genset communicate with the battery bank to regulate the level at which the generator runs at (ideally 80%)? Charge the batteries with whatever balance of power is available at maximum efficiency.
- Transportability, security of system during movement. (AF and Navy do not want to transport because of Li-ion batteries).
- Lower voltage (DC) to make the system easier to maintain at user levels versus needing specialized high voltage specialists.

3.2 Energy Informed Operations-Central (EIO-C)

The Soldiers offered comments on EIO-C, which are presented in the sections below.

3.2.1 Employment of EIO-C

The Soldiers made the following observations regarding the employment of EIO-C:

- Likely best for a light infantry unit with 400-500 Soldiers.
- Discussion regarding the maximum amperage of the system and how the 200 Amps limitation of each IPD would be managed within the grid.
- If the grid eliminates/reduces the need for spot generation, how does this impact the unit's MTOE (e.g. do they lose dedicated generators currently on their MTOE)
- Limitation on distance between loads (voltage drops).
- Could be used during retrograde operations (e.g., when power plant is being dismantled)?

3.2.2 Supportability of EIO-C

Comments regarding supportability are captured as follows:

- Generator mechanic could assist in basic maintenance but any detailed repairs would either require additional training for the Soldiers, or dedicated contractor technicians.
- Detailed, well-documented training and instructions could allow some maintenance to be performed by the unit end users.

3.2.3 Maintainability of EIO-C

Soldiers provided feedback on maintainability issues as follows:

- Control (locking) of the system to avoid another unit inadvertently changing the settings and effecting power supplied.
- What would the requirement be for 200A cables (size, weight, length would be extensive).

3.2.4 Potential Improvements to EIO-C

Soldiers provided input on potential improvements as captured below:

- Safety protocols and fail-safe procedures must be implemented to avoid possible over current on the boxes, if system communications fail.
- The loads should drive the generator operations coming on/off line. Additional load should be commensurate with the size of the generator coming on line.
- Combine HPT and EIO-C systems. Excess power could supply HPT batteries.
- Are all the paralleling challenges being addressed (i.e., phase, frequency, voltage)?

3.3 PowerShade (PSHADE)

The Soldiers provided feedback on PSHADE along these lines:

3.3.1 Employment of PSHADE

Soldiers' feedback and concerns regarding PSHADE use were captured as follows:

- Used for small power requirements, perhaps tents at pre-deployment locations.

- The advantage of the additional power generated is outweighed by the additional logistical and manpower requirements of the system.
- A unit would carry an additional 5K generator, rather than carry this system.
- Does power generated from this system bring a generator off line? If not, Soldiers are not interested.
- Cost benefit analysis required to determine payoff.
- System adds equipment for each tent (item being shaded.
- Signal units may like this system (if it's light enough).
- Could be used in training sites.
- Footprint of camp not impacted.

3.3.2 Supportability of PSHADE

Soldiers voiced their concerns of various aspects of supportability as follows:

- If one panel goes down, is the whole system off line?
- What is the weight comparison compared to traditional camouflage netting?

3.3.3 Maintainability of PSHADE

Maintainability issues from Soldiers are captured below:

- It's going to get dirty quickly and lose capacity. Needs water to clean, which is scarce in small sites. What is the durability in wind?
- Do you need to lower the system to the ground to perform maintenance on it?
- No known MOS for maintaining this. At Bagram, contractors had to maintain all solar.
- Concerns with durability of tent and strap material.
- Anything above arm's range is not good; something at ground level would be better.

3.3.4 Potential improvements to PSHADE

Soldiers provided recommendations as follows:

- Solar sticks are better.
- Weight is a key attribute and challenge.
- Can the solar panels be detached from the tent versus being part of the tent?

3.4 Deployable Metering and Monitoring System (DMMS)

Soldiers provided input to the DMMS (Figure E-4) in the following manner.

3.4.1 Employment of DMMS

Soldiers thought that the DMMS could be used in the following applications:

- Engineers concerned about power requirements.
- Large bases (e.g., FOB).
- Field Hospitals.

- More useful during R&D phase of base camp development, not in a deployed environment.
- Any size camp before hardwiring and going to commercial power.
- Good for any base commander, since they need to report on fuel usage, etc.

3.4.2 Supportability of DMMS

Soldiers did not directly address supportability issues on the DMMS. However, some indirectly related comments are captured below:

- Any more information equals data overload. Too much information (at least at the junior NCO level). Not that useful to Soldiers (at lower levels), rather more for people assessing the power at a camp.
- Secured information, so base layout is not available to everyone. Security – Accreditation is key.

3.4.3 Maintainability of DMMS

Soldiers did not comment on maintainability issues of the DMMS.

3.4.4 Potential improvements to DMMS

Soldiers provided input on potential improvements as follows:

- Can it be incorporated into IPD to remove additional hardware?
- Improve case configuration. The case needs to be off the ground, like PDISE.
- Little J plug to genset?
- Could use wireless interface. Keep data secure, eliminate IPD and large cables.

4 Conclusions

Soldiers' input will be instrumental to the implementation of technical improvements to the aforementioned technologies and to shape doctrinal operational concepts for the use of such technologies.

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Appendix D.2 MACK and 92G Report

MODULAR APPLIANCES FOR CONFIGURABLE KITCHENS (MACK) FOCUS GROUP REPORT

CBITEC, Fort Leonard Wood, MO – 22 April 2015

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Executive Summary

Eleven Soldiers participated in a focus group at the Contingency Basing Integration Technology Evaluation Center (CBITEC) at Fort Leonard Wood, MO, on 22 April 2015 to discuss their experience training on and operating the Containerized Kitchen - Improved (CK-I) and MACK. All participants were Food Service Specialists (92G).

Positive Features:

- CK-I and MACK layout superior to CK
- Two ovens (bigger than CK oven)
- Oven racks and fans
- Improved food quality from ovens
- More efficient meal preparation
- Safer work environment (does not get as hot as CK)
- Lighting
- Can cook three items on MACK griddles without cross-contamination
- Griddle height
- Number of serving wells and height of serving line

Suggestions for Improvement:

- Make trailer-mounted
- Decrease kitchen setup time
- Add tray pack heater and small fridge to the MACK
- Add table next to stove/griddles for pans
- Larger grease traps
- Put grease traps on side of griddle and not above controls
- More durable griddle surfaces
- Improve temperature consistency between all griddles
- Add thermometers to griddles
- Longer griddles
- Hotter skillets (i.e. reduce the time needed to bring to temperature)
- Non-stick cooking surface for skillets
- Increase capacity of skillets to 15-20 gallons
- Add separate water spigot for boiling water
- Add "adjustment" to raise skillet off of heat source
- Add vents for steam in skillet covers
- Improve ease of use of skillet covers
- Add thermometers to outside of oven doors
- Slide-out oven racks
- Decrease pre-heat time for ovens
- Bigger opening for serving line drain
- Serving line needs to be leveled or slanted toward the drain
- Improve quality of serving well gaskets
- Add heat guard and sneeze guard to serving line
- More warming cabinet space

1 Introduction

Sustainability Logistics-Basing Science and Technology Objective – Demonstrations (SLB-STO-D) requested support from the Consumer Research Team (CRT) to conduct a focus group on the Modular Appliances for Configurable Kitchens (MACK). The MACK was one of several candidate technologies that was part of a 1000 personnel camp demonstration located at the Contingency Basing Integration Technology Evaluation Center (CBITEC) at Fort Leonard Wood, MO. The goal of this focus group was to collect qualitative feedback from Soldiers who had trained on and spent time operating the Containerized Kitchen - Improved (CK-I) and candidate appliances. Eleven Army reservists from the 92nd Military Police Battalion and 5th Engineers Battalion of the 4th Maneuver Enhancement Brigade (MEB) participated in this focus group that was conducted on 22 April 2015.

2 Participants and Method

Soldiers met with an engineering psychologist from the CRT to discuss their experience with the CK-I and MACK. A discussion guide was followed, which listed topics to be discussed during the focus groups such as maintainability of the system, best uses of the system, ideal camp size for the technology, as well as recommendations for improvement. Soldiers were asked to give candid feedback in order to help improve the acceptability of the systems. Notes were taken by the SLB-STO-D team and an audio recording was transcribed following the completion of the focus group. Though eleven Soldiers participated in the focus group, only ten Soldiers provided information about their age, rank, MOS, and years in service. Participants' ages ranged from 18 to 33 years, with a mean of 27.1 years. Their ranks were PV1 (n=1), PFC (n=2), SPC (n=5), SGT (n=1), and SSG (n=1). Years in service ranged from 0-13 years, with a mean of 3.09 years. All of the participants were Food Service Specialists (92G).

FOCUS GROUP PARTICIPANTS				
ID#	**AGE**	**RANK**	**MOS**	**YEARS IN SERVICE**
1	29	SPC	92G	2
2	28	PFC	92G	0
3	29	SPC	92G	2
4	30	SPC	92G	2
5	27	SPC	92G	2
6	18	PV1	92G	0.42
7	26	PFC	92G	2
8	33	SSG	92G	13
9	27	SGT	92G	5
10	24	SPC	92G	2.5
MEAN:	**27.1**			**3.09**

The Soldiers were asked to indicate which kitchen systems they have used before (if any), with their options being Containerized Kitchen (CK), Mobile Kitchen Trailer (MKT), Assault Kitchen (AK), Force Provider Electric Kitchen, Force Provider Expeditionary Tri-Con Kitchen, and Kitchen, Company Level, Field Feeding (KCLFF). Five Soldiers had experience with the AK, seven Soldiers had experience with the CK, six Soldiers had experience with the MKT, and one Soldier had experience with the KCLFF. None of the participating Soldiers had experience with the Force Provider Electric Kitchen or the Force Provider Tri-Con Kitchen.

Three Soldiers had experience cooking for 1000 personnel in the CK at NTC and one Soldier had experience cooking for 2000 personnel in the DFAC.

These Soldiers were given an overview of the MACK components by a Senior NCO 92G from the SLB-STO-D who is familiar with the equipment. The NCO oversaw the training and execution of the field feeding exercise. The Soldiers' training included a description of the CK-I, an overview of the new features of the MACK components, and information pertaining to the safety requirements of the equipment. In addition, the Soldiers prepared 200 unitized group ration A (UGR-A) Lunch/Dinner menu # 7 (steak) meals as a practice session in order to familiarize themselves with the CK-I and MACK components and to serve as a pilot run for the data collection procedures associated with obtaining fuel, water, and waste measures as part of the SLB-STO demonstration. This UGR-A meal was selected for the pilot and for the data collection as it required the use of the griddle skillet, and oven and is one of the more challenging UGR-A meals to prepare. In addition, the Soldiers prepared a second UGR-A menu (Menu #5; Sweet Fire Chicken/Happy Family) for 200 personnel as part of the SLB-STO-D VIP day.

3 Results

3.1 Initial Impressions, Layout, and Design

The Soldiers were first asked to discuss their initial impressions of the MACK and of the design and layout of the kitchen's space. Overall, the Soldiers thought that the CK-I and MACK setup was superior to the CK: "I think it made sense— I think it made a lot more sense than the CK. I like the fact that the cooking area was sort of in the middle, where everybody could move around and at the same time, you could serve… and you won't be in the way." One Soldier, however, mentioned that "most of the time, the CK would be mounted to a trailer… so you have ways to level it, and that's important— that's critical to what we do. Maybe next time have it trailer-mounted." Another Soldier expressed concern about setting up the CK-I on uneven ground: "…right now it's on flat ground, so I wouldn't know how to set this up [on ground that isn't flat]… if we don't know how to set it up, then we might not do things properly." This Soldier would have liked to have learned how to set up the kitchen first, but thought that cooking in the kitchen was easy once it was all set up. Other Soldiers agreed that as long as they were able to get the kitchen leveled, "everything was good."

Next, the Soldiers discussed differences between the CK-I and MACK and the "regular" CK. All of the Soldiers agreed that there were significant layout differences between the kitchens. One Soldier explained that the CK has a large griddle with the serving line right by it, which is a

problem because those cooking and those serving get into each other's way. This Soldier believed that the CK-I's layout was a “good improvement” because they [griddle and serving line] are “not right by each other. The serving line is away from us cooking and we won't bother anyone.” Similarly, another Soldier said that there is a lot more space in the CK-I and that the layout made things more convenient: “because the table is separate from the griddle, the servers could serve without any interruptions.” Moreover, one Soldier commented that the ovens were a lot bigger than the one in the CK, and liked that there were two of them so they could prepare meals more quickly, which was something that all the Soldiers agreed was important. They said it would typically take about four hours to cook for 800 personnel with the CK appliances, while it only took about 2.5 hours with the MACK.

The Soldiers also thought that environmentally, the CK-I was “wonderful” and a “major improvement” over the CK because the high temperature in the CK often caused delays due to personnel having to take breaks and get rehydrated, even on days that were not very hot. Therefore, not only was the CK-I and MACK an improvement by allowing the Soldiers to prepare meals more efficiently, it was also a safer environment to work in.

The Soldiers then shared two suggestions for improvement: the first suggestion was to add a tray pack heater to the MACK, which would be necessary to prepare unitized group ration heat-and-serve meals (UGR H&S). Next, they suggested adding a table next to the stove that the cooks could put pans on. One Soldier mentioned that the CK currently has a table like this in the middle, and all of the Soldiers agreed that a table in the CK-I would be beneficial.

Following these suggestions, one Soldier stated that "92G's tend to adjust to the equipment that we have, so this CK-I might not have all of the operating space that we want it to have, but we definitely know that we could adjust to this kitchen.”

The Soldiers were then asked for their thoughts about what type of environment the CK-I and MACK are best suited. All of the Soldiers agreed that the MACK would be practical in an operational environment, and they thought that a 1000 personnel camp would be an optimal place to use it. They explained that it took them 45 minutes to cook for a small number of people (150 personnel), which made them believe that the MACK is "too much for 45 minutes" and that it has the capability to efficiently prepare meals for a greater number of people.

Next, the Soldiers said that the CK-I was “perfectly lit” and that the lighting was brighter than the lighting in the CK. One Soldier also described the lighting as more “natural” and said “it's not really hurting your eyes.” They said that although they didn't have a chance to cook while it was dark outside, they closed one of the major flaps of the CK-I and were still able to see what they were doing. They explained that adequate lighting is important to both working efficiently and also for safety reasons (e.g. not burning themselves and being able to see if anything falls into the food). The Soldiers were then asked if they needed any integrated lighting (e.g. above the stove), and the Soldiers all agreed that no, they did not need any integrated lighting because “there was light everywhere I worked.”

3.2 Griddles

One topic of particular interest to the Soldiers was how the MACK's griddle configuration compared to the CK's griddle configuration. One Soldier said that he loved the MACK’s griddles because they are "stationary," easy to clean, and “a lot more convenient than the big long one.” Three of the Soldiers preferred the CK’s single griddle, while seven Soldiers preferred the MACK’s three griddles. The Soldiers who preferred the single griddle preferred it because they already had experience with it and because they liked being able to put everything onto the griddle at the same time. The Soldiers who preferred the three griddles preferred them because they were able to cook three different foods at one time without cross-contaminating them or having the juices "run into each other." Regardless of which griddle(s) they preferred, all of the Soldiers thought the height of the MACK's griddles were good. The Soldiers then gave an example about the steak meal they prepared with the MACK, and said they were able to cook the onions and peppers without having the juices drain into the steak. Another example they gave was cooking a breakfast meal of eggs and hash browns; they would typically have to cook one food item at a time and have to wash the griddle between each item. With the MACK, however, they would be able to cook eggs and hash browns at the same time.

The last topic of discussion for the griddles was suggestions for improvement. All of the Soldiers agreed that the grease traps on the griddles were too small, and they suggested making them the length of the griddle. They also said that the grease traps should be on the side of the griddle and not above the controls because the grease could potentially spill out onto the controls. They then suggested making the surface of the griddles harder or more durable because they could see dents and scrapes in them and saw pieces of the griddles' surface in the food they had prepared. As a result of this, the Soldiers believed that the griddles "wouldn't last very long." Next, the Soldiers explained that the middle griddle performed differently than the outer griddles: “when we cooked the steak, it [the middle griddle] seemed like it was boiling the steak and not grilling.” The Soldiers said that they had to turn the temperature of the middle griddle up higher than the outer griddles in order for the steak to cook as quickly and for the steaks to grill, not boil. They believed that the addition of thermometers on the griddles would allow them to check the temperatures more easily and might help to mitigate the disparate griddle temperatures. The Soldiers also thought that they could benefit from a griddle that was a “couple inches” longer, because having the extra cooking surface would help when they are cooking for 1000+ people. They said that they can currently fit about 15 steaks on the griddle, but 20 steaks would be optimal. One Soldier thought it would be beneficial to be able to remove the separators between the griddles and have an “adapter” that they could use to convert the three griddles into one long griddle. Another Soldier suggested keeping the divider, but having two griddles instead of three (with one griddle being 2/3 of the length, and the other being 1/3). Lastly, the Soldiers suggested having a small table or "pan holder" (or both) next to the griddles to make it more convenient to transfer food from the griddles; they explained that during preparation of the steak meal, they would have to transfer the steaks to a table on the other side of the kitchen.

3.3 Skillets

One of the main areas of concern related to the MACK skillets was that they did not get hot enough. One Soldier gave an example about using the skillet to boil water for coffee and said that even after an hour, the water had not boiled, whereas boiling the same amount of water in the CK would only take about 10-15 minutes. The Soldiers were then asked to explain how they used the MACK to make coffee. They explained that they boiled water in the skillet and had to ladle it into insulated containers since they were instructed not to use the tilt function since the skillets are still under development. The Soldiers then compared the MACK's method of preparing coffee to how they would have done it in the CK, and they said that the tilt function would decrease prep time (if it was safe to pour the water that way), and they believed it would be quicker than making coffee in the CK if the water would heat to temperature at a comparable rate. One Soldier, however, said that making coffee is a "totally separate field" from food service and that there should be something separate just for making coffee (e.g. a spigot that has boiling water). The other Soldiers agreed that this would be helpful. They also agreed that it would be an improvement if the skillet had closer to a 15 or 20 gallon capacity instead of a 10 gallon capacity.

The Soldiers were then asked to discuss their thoughts about having a skillet as part of the MACK versus having square heads and stock pots that are typically used in the CK. One Soldier said it would be helpful if they had something like that [square heads or stock pots] in addition to what is part of the MACK.

Next, the Soldiers discussed how the skillets would continue to cook the food long after turning them off. The Soldiers gave an example about vegetables they were cooking in the skillets and said that even 45 minutes after turning them off, the vegetables continued cooking and got burnt on the bottom. One Soldier suggested putting in an “adjustment” that would raise the skillet up off the heat source so that food would not continue cooking. Related to that, one Soldier compared the skillet to a stove at home: “if you turn the burner off at home and you leave the pan of vegetables on the burner, it’s going to continue to cook, so you have to keep that in mind. Maybe it’s not the design of the skillet, maybe we just have to get it off there. Transfer it sooner. That’s why we do this—it’s a training experience.” In response to that Soldier’s comment, another Soldier explained that sometimes they have to keep food on the skillet to keep it warm, and that “it shouldn’t be cooking 45 minutes to an hour after we turn it completely off.”

The moderator then asked the Soldiers if it would be useful or necessary to have a vent in the covers to let steam out. One Soldier said that they tried letting steam out but got burned by the steam: “it was real bad. If it’s boiling, it’s going to burn you regardless.” When asked if a vent for steam was “high on their wish list,” most of the Soldiers commented that they had not thought about it before, but after being mentioned, then yes, it is high on their wish list.

The Soldiers then shared two additional suggestions for improvement. The Soldiers' first suggestion was to make a non-stick cooking surface for the skillet, which they believed would be "ideal." The second suggestion was to improve the ease of use of the skillet's cover: “it was a struggle getting it back on. You can lift it up all day, but it’s hard to get back on… you have to get it just right to get it on there.” All of the Soldiers agreed that the cover needed some

improvements. One Soldier said that the cover mechanism should be more like what is in the CK, so instead of having to figure out the “trajectory” of the cover to fit onto the skillet, just have one that “sits on top of the lip of the skillet.” In other words, the Soldiers would prefer skillet covers that can simply rest on top of the skillet without worrying about whether the cover is being put onto the skillet properly. Another Soldier said that he doesn’t think covers are even necessary because they “aren’t used to covering things anyway on the CK. We never really covered except for boiling water. We didn’t use covers for pots and stuff like that. We didn’t have a reason to use the covers.”

3.4 Ovens

Overall, the Soldiers were pleased with the MACK ovens. They liked that the MACK included two ovens as opposed to the one oven that they would typically have in a CK. They also liked that the MACK ovens were larger than the CK oven and said that even if the MACK only had one oven, it would still be better than the CK oven because of its bigger size. One Soldier liked that it “had 10 racks so you could put 10 items in there and get things done faster.” The Soldiers also liked the fans in the ovens because it mitigated uneven cooking that could occur when opening the oven doors. When asked about the oven timers, the Soldiers all agreed that having a timer on the ovens is necessary because although their cell phones have timers, those cooking "would not be paying attention to their cell phones while they're cooking."

The Soldiers then discussed some suggestions for improvements to the ovens. One suggestion was putting thermometers on the outside of the oven doors so that they would not have to open the doors in order to check the temperature. Another suggestion was to have oven racks that can slide out. They said that this improvement would be high on their wish list because without racks that slide out, they could potentially burn themselves when trying to get items out of the oven. Next, the Soldiers said that although the temperature range of the ovens was good, it took a long time to reach the desired temperature (30-45 minutes to pre-heat), which was a problem for their time management: “we need to work efficiently and get that meal out in a good amount of time.” The Soldiers then discussed the idea of having a window in the oven door so that they would not have to open the oven to check on the food; one Soldier explained that when he opens the oven while cooking, "steam comes out and gets you in the face." Although the Soldiers thought a window in the oven could be beneficial, one Soldier explained that it's not a good idea because "this is field equipment and glass breaks." (At the conclusion of the focus group, the Soldiers learn that adding a window is not viable because it would require the oven to need light and electricity, and the window does not provide enough value to outweigh the costs and risks of having them.)

The Soldiers were then asked if they noticed a difference in the taste or quality of the food that they prepared in the ovens. Some of the Soldiers commented that they noticed an improvement because the food didn’t taste like gas and there was less smoke: “with the MBUs with the MKT on the CK, you’ll taste gas;” “just tasted better. There wasn’t as much smoke.”

3.5 Serving Line

All of the Soldiers liked the number of serving wells and the height of the MACK's serving line, but they also shared a few suggestions for improvements. All of the Soldiers agreed that the serving line needed a bigger opening for the drain because it "takes forever" for the water to drain out. They also said that the serving line is "not level," so the leveling either needs to be corrected or should be slanted down toward the drain so that the water flows out more easily. Some other suggestions the Soldiers had were to improve the durability of the gaskets around the serving wells, to add a heat guard (like on the CK) to prevent burns, and to add a sneeze guard (also like on the CK) because "people are reaching out like 'I want that right there' and you don't know if they're using hand sanitizer."

The Soldiers were then asked to share their thoughts about hypothetical improvements that might be incorporated into future iterations of the CK-I and MACK. The first idea presented to the Soldiers was having a convertible serving line that could become usable counter space. Overall, the Soldiers liked this idea, but still preferred the idea of having fold-out tables or pot holders on either side of the cooking surfaces. One Soldier said that using the serving line as a table would work for the serving line side, but they would still need pot holders for the other side. When asked to rate the priority of this on a scale from 1 to 10, the Soldiers said it was about an 8.

Next, the Soldiers were asked for their thoughts about a serving line that could heat boil-in-bag items. Overall, this was not something the Soldiers wanted or needed. One Soldier said that it would cause them to use more water unnecessarily because they could just be using the griddle. Another Soldier said that it was "not a good idea because say you run out of time, you still have the boil-in-bag items in the serving area and you have to set up the serving area now."

The Soldiers were then asked if having two warming cabinets under the serving line would be something they would like. All of the Soldiers agreed that having a warming cabinet is "essential" and that they "definitely need one," but they would not want the cabinets to be low to the ground because they would have to "bend down and will have water and you'll have to lift it, so it's better to have it [the warming cabinet] level." This means that they would prefer to have higher warming cabinets, which makes them easier and safer to use. They also said that a lot more space would be needed in order to have the warming cabinets located there. When using the provided warming cabinet during their meal preparation the day before, the Soldiers stated that the cabinet was "packed" and they "need bigger." The Soldiers rated the importance of a bigger warming cabinet as a 10+ on a scale from 1 to 10.

When asked about adding a chilling capability to the serving line, all of the Soldiers shared that it would be unnecessary because the only items they serve cold are fruit and salad.

3.6 Additional Comments

At the end of the focus group, the CK-I and MACK product engineers were able to speak to the Soldiers about any final comments and suggestions, and shared with the Soldiers what improvements are currently being made to the MACK. The Soldiers said that drawers for utensils and cabinets for pots and pans would be very useful, and that they would also like a small fridge in the MACK, like there is in the CK. When asked about the need for shelving and baking racks, the Soldiers said that they would be “useful equipment but do not necessarily need to be in the unit.” The engineers then asked the Soldiers what range of people the MACK would be appropriate to prepare meals for and the Soldiers said about 500 to 1000 personnel, cooking 2 meals per day. The Soldiers then explained that although it could be used at a smaller camp, doing this would be “selling it short” because the CK-I and MACK is capable of more. In other words, the Soldiers believed that the CK-I and MACK would not be used to their fullest potential at a camp smaller than 500 personnel. The Soldiers were then interested to know how long it would take to set up the entire CK-I and MACK in a field environment because “that’s number one importance.” The engineers said it is supposed to take about 45 minutes to set up with four people, but could be as little as 30 minutes if all four people had experience setting up the kitchen. The Soldiers then asked if it would be possible to bring the setup time down even more because in some situations, they may not have 45 minutes to set up. They then expressed their concern that setting the kitchen up and tearing it down quickly could eventually “take a toll” on the kitchen and its appliances.

ANNEX E – DATA CATALOG

Collection Date	Data Set	DESERT
Monday 04/13/2015	DS-001	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150413_v1-3_D authenticated.xlsx
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150414_v1-4_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150415_v1-4_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150416_v1-4_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150417_v1-4_D authenticated.xlsx
Saturday 04/18/2015	DS-006	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150418_v1-4_D authenticated.xlsx
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150419_v1-5_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150420_v1-5_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150421_v1-5_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150422_v1-5_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-0680-DESERT_CBITEC-Demo1-1000-20150423_v1-5_D authenticated.xlsx
Friday 04/24/2015	DS-012	N/A
Saturday 04/25/2015	DS-013	N/A

Collection Date	Data Set	MACK
Monday 04/13/2015	DS-001	N/A
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150414_v1-5_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150415_v1-6_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150416_v1-6_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150417_v1-6_D authenticated.xlsx
Saturday 04/18/2015	DS-006	N/A
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150419_v1-5_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150420_v1-5_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150421_v1-5_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150422_v1-6_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-0700-MACK_CBITEC-Demo1-1000-20150423_v1-5_D authenticated.xlsx
Friday 04/24/2015	DS-012	N/A
Saturday 04/25/2015	DS-013	N/A

Collection Date	Data Set	EIO
Monday 04/13/2015	DS-001	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150413_v1-4_D authenticated.xlsx
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150414_v1-4_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150415_v1-4_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150416_v1-4_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150417_v1-4_D authenticated.xlsx
Saturday 04/18/2015	DS-006	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150418_v1-4_D authenticated.xlsx
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150419_v1-5_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150420_v1-4_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150421_v1-5_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150422_v1-5_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-0360-EIO_CBITEC-Demo1-1000-20150423_v1-5_D authenticated.xlsx
Friday 04/24/2015	DS-012	N/A
Saturday 04/25/2015	DS-013	N/A

Collection Date	Data Set	PSHADE
Monday 04/13/2015	DS-001	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150413_v1-4_D authenticated.xlsx
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150414_v1-5_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150415_v1-6_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150416_v1-6_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150417_v1-6_D authenticated.xlsx
Saturday 04/18/2015	DS-006	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150418_v1-6_D authenticated.xlsx
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150419_v1-6_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150420_v1-6_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150421_v1-6_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150422_v1-6_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150423_v1-6_D authenticated.xlsx
Friday 04/24/2015	DS-012	EDVT_DDS_EE-0290-PSHADE_CBITEC-Demo1-1000-20150424_v1-4_D authenticated.xlsx
Saturday 04/25/2015	DS-013	N/A

Collection Date	Data Set	HPT
Monday 04/13/2015	DS-001	N/A
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150414_v1-2_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150415_v1-2_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150416_v1-1_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150417_v1-1_D authenticated.xlsx
Saturday 04/18/2015	DS-006	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150418_v1-1_D authenticated.xlsx
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150419_v1-3_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150420_v1-3_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150421_v1-3_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150422_v1-3_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-1210-HPT_CBITEC-Demo1-1000-20150423_v1-3_D authenticated.xlsx
Friday 04/24/2015	DS-012	N/A
Saturday 04/25/2015	DS-013	N/A

Collection Date	Data Set	SIP-HUT
Monday 04/13/2015	DS-001	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150413_v1-2_D authenticated.xlsx
Tuesday 04/14/2015	DS-002	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150414_v1-6_D authenticated.xlsx
Wednesday 04/15/2015	DS-003	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150415_v1-6_D authenticated.xlsx
Thursday 04/16/2015	DS-004	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150416_v1-6_D authenticated.xlsx
Friday 04/17/2015	DS-005	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150417_v1-6_D authenticated.xlsx
Saturday 04/18/2015	DS-006	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150418_v1-6_D authenticated.xlsx
Sunday 04/19/2015	DS-007	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150419_v1-6_D authenticated.xlsx
Monday 04/20/2015	DS-008	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150420_v1-6_D authenticated.xlsx
Tuesday 04/21/2015	DS-009	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150421_v1-6_D authenticated.xlsx
Wednesday 04/22/2015	DS-010	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150422_v1-7_D authenticated.xlsx
Thursday 04/23/2015	DS-011	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150423_v1-7_D authenticated.xlsx
Friday 04/24/2015	DS-012	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150424_v1-6_D authenticated.xlsx
Saturday 04/25/2015	DS-013	EDVT_DDS_EE-1220-SIP-HUT_CBITEC-Demo1-1000-20150425_v1-4_D authenticated.xlsx

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ANNEX F – DATA MANAGEMENT PROCESS FINDINGS AND DISCUSSIONS

Before, during, and after demonstrations the SLB-STO-D in general, and the EDVT specifically, assess the efficiency and accuracy of the data management processes associated with field demonstrations. Much of this discussion takes place during the meetings of the Data Authentication Group (DAG). A summary of these types of discussions in each DAG meeting follows.

15 April: This demonstration at CBITEC was the first field data collection event during which the EDVT utilized the workbook deliverable format. There was much discussion about (a) sparse matrices and (b) how to mark cells with bad or questionable data. There was no consensus among the group about how to mark questionable data. The path forward was to use the comment section in the workbook to identify the questionable data. End users of the data workbooks could then identify and modify the cells in a manner that best suits their purpose. During this initial session, as is typical with the first DAG, only one PSHADE file and one DESERT file were authenticated during this session. Other files, including ones from HPT and SIP-Hut, had issues to be resolved and resubmitted later.

20 April: The team found it challenging to conduct a meaningful DAG session during execution of the demonstration. The functional teams are not very deep with respect to personnel and all have tasks they are required to execute. Much was learned about advance preparation of the deliverables. It would be very helpful to lock down the format of the deliverables prior to demo, then resist all "good ideas" during demo. Again there was a low production rate in this DAG – only one SIP-Hut file and one HPT file were authenticated during this session. Other files, including ones from DESERT, MACK, and PSHADE, had issues to be resolved and resubmitted later. EDVT must find a way to better conduct quality checks on data prior to presenting to the DAG.

23 April: By this time, the number of files to be reviewed and the number of repairs required to the files was really starting to mount. The SLB-STO-D took on a much larger data management task with the same number of resources, so the process was much less efficient at this demo. To accomplish the authentication task, the team took a two-prong approach – first, prioritize the files that must be authenticated before SMEs were no longer available, and second, review and discuss each of the different types of files to establish a knowledge base within the DAG. Only one EIO-C file was authenticated during this session.

27 April: This DAG was the first held on site after data collection was complete. The team talked about some of the lessons learned with this demonstration as it relates to data collection and data management. A very large amount of data was handled for this demonstration. Every member of the EDVT worked an incredible number of hours to manage this task, including processing data and solving problems, many with external sources. The SLB-STO-D and EDVT must make changes moving forward to handle these data management tasks better in future demos. Here are some options:

- Add manpower, like a second shift, to better handle the data and not cause people to work 90-hour weeks.
- Collect less data either in the number of data elements or in the number of collection days. One option would be to instrument and then run a pilot. Cease data collection until that pilot dataset is thoroughly processed and authenticated, implying that all problems with data collection are solved. Then begin official data collection. Maybe run for 3-4 days rather than 12 days.
- Some combination of the above.

28 April: The team authenticated six files for SIP-Hut. The others were graded as "limited use" due to data gaps. EIO-C files had significant processing issues and were returned for repair and resubmission.

29 April: Completed authentication of the EIO-C datasets. The WWT-Bio datasets were missing power data and scheduled for later review.

21 May: This DAG session was conducted at NSRDEC in conjunction with the SLB-STO-D's Quarterly In-Progress Review. The DAG reviewed the power, water, and waste data for the WWT-Bio. No datasets were authenticated. More information was needed from TARDEC and/or their SMEs to explain the power results in relation to how the system operates (the vendor later provided suitable explanations for the power data). The values of volume for wastewater IN versus treated water OUT were too far apart. The group decided, based on the recommendation from the instrumentation lead, to accept data from the onboard Dynasonic flow meter that monitored wastewater IN and disregard the data from the Badger flow meter that measured treated water OUT.